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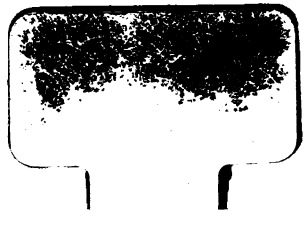

TABLES

GIVING

HYDRAULIC MEAN DEPTH AND AREA OF CIRCULAR SEWERS,

FROM 3 INCHES TO 30 INCHES IN DIAMETER,

WHEN

FLOWING ONE-QUARTER, ONE-THIRD, TWO-THIRDS, THREE-QUARTERS FULL, AND FULL;

ALSO,

THEIR DISCHARGE AND VELOCITY AT VARIOUS GRADIENTS.

CALCULATED BY

RODOLPH DE SALIS, B.A.,

ASSOC. M. INST. C.E.

LONDON:

E. & F. N. SPON, 16, CHARING CROSS.

NEW YORK: 35, MURRAY STREET.

1884.

[*Price One Shilling.*]

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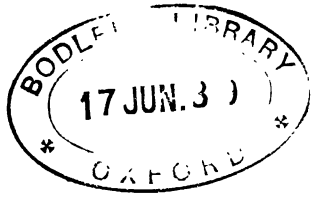
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PREFACE.

THE following Tables are designed to facilitate the calculation of the velocity of flow in and discharge from circular pipes of various sizes, flowing from one-quarter full to full.

TABLE 1 gives the hydraulic mean depth and sectional area of sewers from 30 in. to 3 in. in diameter, when flowing one-quarter, one-third, two-thirds, three-quarters full, and full.

TABLES 2 to 14 give the velocity of flow in and discharge in feet per minute from pipes 30″, 27″, 26″, 24″, 21″, 18″, 15″, 14″, 12″, 10″, 9″, 8″, 6″, 4″, and 3″ in diameter, when flowing one-quarter, one-third, two-thirds, three-quarters full, and full, under various falls.

The Tables are calculated from the formula $V = 55\sqrt{H \times 2f}$, when V = velocity in feet per minute.

H = hydraulic mean depth in feet.

f = fall in feet per mile.

The velocity for a fall of 1 ft. is $55\sqrt{2H}$; this is given in each of the Tables. As the velocity increases as the square root of the fall, the velocity due to any fall not given in the Tables can be found by multiplying the tabular velocity for 1 ft. by the square root of the fall. Thus a 9-in. pipe flowing full has

a velocity of 33·7 ft., with a fall of 1 ft. per mile; to find the velocity due to a fall of 16 ft. per mile, we have $33 \cdot 7 \sqrt{16} = 134$, which is the required velocity.

As discharge = velocity × area, it increases in the same ratio as the velocity, and can be calculated in a similar manner.

In circular pipes the area varies as the square of the diameter. The hydraulic mean depth varies as the diameter. The area and depth for any pipe not given in the Tables can therefore be readily calculated from that of a pipe 1 ft. in diameter, which is given in Table No. 1. Thus the area of flow in a pipe 3 ft. in diameter and one-quarter full is $\cdot 1535 \times 3^2 = 1 \cdot 3815$, and the hydraulic mean depth is $\cdot 1466 \times 3 = \cdot 4398$.

The area of a circular pipe flowing half full is half that of a similar pipe flowing full. The hydraulic mean depth, or $\frac{\text{area}}{\text{wetted perimeter}}$, is the same for a half as for a whole circle, and equals $\frac{\text{diameter}}{4}$. The velocity in a pipe flowing half full is therefore the same as when full, and the discharge one-half the discharge from a full pipe. This being the case, it was unnecessary to tabulate the flow, velocity, area, or hydraulic mean depth for the half area.

The discharge is given in cubic feet per minute. To convert this into gallons in 24 hours, multiply by 9151 or Log. 3·96147, or approximately by 9000.

1, Westminster Chambers, S.W.

TABLES.

TABLE GIVING HYDRAULIC MEAN DEPTH AND AREA OF SEWERS IN FEET, TWO-THIRDS, THREE-FOURTHS

Size of Pipe.	One-quarter Full.				One-third Full.				Two-thirds	
	Hydraulic Mean Depth.	Equivalent Logarithm.	Area.	Equivalent Logarithm.	Hydraulic Mean Depth.	Equivalent Logarithm.	Area.	Equivalent Logarithm.	Hydraulic Mean Depth.	Equivalent Logarithm.
30″	·3666	$\bar{1}$·56415	·9597	$\bar{1}$·98212	·4654	$\bar{1}$·66787	1·4324	0·15606	·7278	$\bar{1}$·86201
27″	·3299	$\bar{1}$·51839	·7773	$\bar{1}$·89060	·4189	$\bar{1}$·62211	1·1602	0·06454	·6627	$\bar{1}$·82130
26″	·3177	$\bar{1}$·50200	·7208	$\bar{1}$·85782	·4034	$\bar{1}$·60572	1·0759	0·03176	·6308	$\bar{1}$·79985
24″	·2932	$\bar{1}$·46724	·6142	$\bar{1}$·78830	·3724	$\bar{1}$·57096	·9167	$\bar{1}$·96224	·5822	$\bar{1}$·76510
21″	·2566	$\bar{1}$·40925	·4702	$\bar{1}$·67231	·3258	$\bar{1}$·51297	·7019	$\bar{1}$·84626	·5095	$\bar{1}$·70711
18″	·2199	$\bar{1}$·34230	·3455	$\bar{1}$·53842	·2793	$\bar{1}$·44602	·5157	$\bar{1}$·71236	·4367	$\bar{1}$·64016
15″	·1833	$\bar{1}$·26312	·2399	$\bar{1}$·38006	·2327	$\bar{1}$·36684	·3581	$\bar{1}$·55400	·3639	$\bar{1}$·56098
14″	·1711	$\bar{1}$·23316	·2090	$\bar{1}$·32013	·2172	$\bar{1}$·33688	·3119	$\bar{1}$·49407	·3396	$\bar{1}$·53102
12′	·1466	$\bar{1}$·16621	·1535	$\bar{1}$·18624	·1862	$\bar{1}$·26993	·2292	$\bar{1}$·36018	·2911	$\bar{1}$·46407
10″	·1222	$\bar{1}$·08703	·1066	$\bar{1}$·02788	·1551	$\bar{1}$·19075	·1591	$\bar{1}$·20182	·2426	$\bar{1}$·38489
9″	·1100	$\bar{1}$·04127	·0864	$\bar{2}$·93636	·1396	$\bar{1}$·14499	·1289	$\bar{1}$·11030	·2183	$\bar{1}$·33913
8″	·0977	$\bar{2}$·99012	·0682	$\bar{2}$·83406	·1241	$\bar{1}$·09384	·1019	$\bar{1}$·00800	·1941	$\bar{1}$·28798
6″	·0733	$\bar{2}$·86518	·0384	$\bar{2}$·58418	·0931	$\bar{2}$·96890	·0573	$\bar{2}$·75812	·1456	$\bar{1}$·16304
4″	·0489	$\bar{2}$·68909	·0171	$\bar{2}$·23200	·0621	$\bar{2}$·79281	·0255	$\bar{2}$·40594	·0970	$\bar{2}$·98695
3″	·0367	$\bar{2}$·56415	·0096	$\bar{3}$·98212	·0465	$\bar{2}$·66787	·0143	$\bar{2}$·15606	·0728	$\bar{2}$·86201

WITH EQUIVALENT LOGARITHMS, WHEN FLOWING ONE-QUARTER, ONE-THIRD, THE VERTICAL HEIGHT, AND FULL.

Full.		Three-quarters Full.				Full.				Size of Pipe.
Area.	Equivalent Logarithm.	Hydraulic Mean Depth.	Equivalent Logarithm.	Area.	Equivalent Logarithm.	Hydraulic Mean Depth.	Equivalent Logarithm.	Area.	Equivalent Logarithm.	
3·4764	0·54112	·7542	1·87750	3·9491	0·59650	·6250	1·79588	4·9087	0·69097	30″
2·8158	0·44961	·6788	1·83174	3·1988	0·50498	·5625	1·75012	3·9761	0·59945	27″
2·6111	0·41683	·6537	1·81535	2·9662	0·47220	·5417	1·73373	3·6870	0·56667	26″
2·2249	0·34730	·6034	1·78059	2·5274	0·40268	·5000	1·69897	3·1416	0·49715	24″
1·7034	0·23132	·5279	1·72259	1·9350	0·28670	·4375	1·64098	2·4054	0·38117	21″
1·2515	0·09743	·4525	1·65565	1·4217	0·15280	·3750	1·57403	1·7671	0·24727	18″
·8691	1·93906	·3771	1·57646	·9873	1·99443	·3125	1·49485	1·2272	0·08891	15″
·7571	1·87914	·3520	1·54651	·8600	1·93451	·2917	1·46489	1·0690	0·02898	14″
·5562	1·74524	·3017	1·47956	·6318	1·80062	·2500	1·39794	0·7854	1·89509	12″
·3863	1·58689	·2514	1·40037	·4388	1·64225	·2083	1·31876	·5454	1·73673	10″
·3129	1·49538	·2263	1·35462	·3554	1·55074	·1875	1·27300	·4418	1·64521	9″
·2472	1·39307	·2011	1·30347	·2808	1·44843	·1667	1·22185	·3491	1·54291	8″
·1391	1·14320	·1508	1·17853	·1580	1·19856	·1250	1·09691	·1963	1·29303	6″
·0618	$\bar{2}$·79106	·1006	1·00244	·0702	$\bar{2}$·84637	·0833	$\bar{2}$·92082	·0873	$\bar{2}$·94085	4″
·0348	$\bar{2}$·54112	·0754	$\bar{2}$·87750	·0395	$\bar{2}$·59650	·0625	$\bar{2}$·79588	·0491	$\bar{2}$·69097	3″

VELOCITY AND DISCHARGE IN FEET PER MINUTE OF A CIRCULAR SEWER 30" IN DIAMETER, WHEN FLOWING ONE-QUARTER, ONE-THIRD, TWO-THIRDS, THREE-FOURTHS THE VERTICAL HEIGHT, AND FULL, WITH A FALL OF ONE TO TWENTY-FIVE FEET PER MILE.

Fall in feet per mile.	Gradient.	One-fourth Vertical Height.		One-third Vertical Height.		Two-thirds Vertical Height.		Three-fourths Vertical Height.		Full.		Fall in feet per mile.
		Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	
1	1 in 5280	47·09	45·19	53·07	76·01	66·36	230·68	67·55	266·76	61·49	301·85	1
2	1 in 2640	66·60	63·91	75·05	107·49	93·84	326·23	95·53	377·26	86·96	426·88	2
3	1 in 1760	81·57	78·28	91·91	131·65	114·93	399·55	117·00	462·05	106·51	522·81	3
4	1 in 1320	94·19	92·49	106·13	152·02	132·71	461·36	135·10	533·53	122·98	603·69	4
5	1 in 1056	105·30	101·05	118·66	169·96	148·38	515·81	151·05	596·50	137·50	674·95	5
6	1 in 880	115·35	110·70	129·98	186·19	162·54	565·05	165·47	653·44	150·62	739·37	6
7	1 in 754	124·60	119·57	140·40	201·10	175·56	610·32	178·72	705·79	162·69	798·61	7
8	1 in 660	133·20	127·82	150·09	214·99	192·06	667·66	191·06	754·52	173·93	853·75	8
9	1 in 586	141·28	135·58	159·20	228·03	199·07	692·04	202·65	800·29	184·48	905·54	9
10	1 in 528	148·92	142·91	167·81	240·37	209·84	729·47	213·61	843·58	194·45	954·53	10
11	1 in 480	156·19	149·89	176·00	252·10	220·08	765·08	224·04	884·76	203·95	1001·11	11
12	1 in 440	163·13	156·56	183·82	263·31	229·87	799·10	234·00	924·10	213·01	1045·63	12
13	1 in 406	169·79	162·95	191·33	274·06	239·25	831·73	243·56	961·83	221·71	1088·33	13
14	1 in 377	176·20	169·10	198·55	284·40	248·28	863·12	252·75	998·14	230·08	1129·41	14
15	1 in 352	182·39	175·03	205·52	294·39	257·00	893·42	261·62	1033·17	238·16	1169·05	15
16	1 in 330	188·37	180·77	212·26	304·04	265·43	922·72	270·21	1067·06	245·97	1207·39	16
17	1 in 311	194·17	186·34	218·79	313·40	273·59	951·11	278·52	1099·89	253·54	1244·55	17
18	1 in 293	199·80	191·74	225·14	322·48	281·53	978·69	286·59	1131·78	260·89	1280·63	18
19	1 in 278	205·27	196·99	231·31	331·32	289·24	1005·51	294·45	1162·79	268·04	1315·72	19
20	1 in 264	210·60	202·11	237·32	339·93	296·75	1031·63	302·10	1193·01	275·00	1349·90	20
21	1 in 251	215·81	207·10	243·18	348·32	304·08	1057·10	309·56	1222·44	281·79	1383·24	21
22	1 in 240	220·88	211·97	248·90	356·52	311·24	1081·98	316·84	1251·24	288·42	1415·79	22
23	1 in 230	225·85	216·74	254·49	364·53	318·23	1106·30	323·96	1279·35	294·90	1447·61	23
24	1 in 220	230·71	221·40	259·97	372·37	325·08	1130·09	330·93	1306·87	301·25	1478·75	24
25	1 in 211	235·46	225·97	265·33	380·05	331·78	1153·40	337·75	1333·82	307·46	1509·24	25

VELOCITY AND DISCHARGE IN FEET PER MINUTE OF A CIRCULAR SEWER 27" IN DIAMETER, WHEN FLOWING ONE-QUARTER, ONE-THIRD, TWO-THIRDS, THREE-FOURTHS THE VERTICAL HEIGHT, AND FULL, WITH A FALL OF ONE TO TWENTY-FIVE FEET PER MILE.

Fall in feet per mile.	Gradient.	One-fourth Vertical Height.		One-third Vertical Height.		Two-thirds Vertical Height.		Three-fourths Vertical Height.		Full.		Fall in feet per mile.
		Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	
1	1 in 5280	44·68	34·73	50·34	38·41	63·32	178·29	64·08	204·99	58·34	231·95	1
2	1 in 2640	63·18	49·11	71·19	82·60	89·55	252·15	90·63	289·90	82·50	328·03	2
3	1 in 1760	77·38	60·15	87·20	101·17	109·67	308·82	111·00	355·05	101·04	401·75	3
4	1 in 1320	89·35	69·46	100·68	116·82	126·64	356·59	128·17	409·98	116·67	463·90	4
5	1 in 1056	99·90	77·65	112·57	130·61	141·58	398·68	143·30	458·37	130·44	518·66	5
6	1 in 880	109·43	85·07	123·31	143·07	155·10	436·73	156·97	502·12	142·89	568·16	6
7	1 in 754	118·20	91·88	133·19	154·53	167·52	471·72	169·55	542·35	154·34	613·68	7
8	1 in 660	126·36	98·23	142·39	165·21	179·09	504·30	181·26	579·79	165·00	656·05	8
9	1 in 586	134·03	104·18	151·03	175·23	189·96	534·88	192·25	614·97	175·01	695·85	9
10	1 in 528	141·28	109·82	159·20	184·71	200·23	563·81	202·65	648·23	184·48	733·49	10
11	1 in 480	148·17	115·18	166·97	193·72	210·00	591·34	212·54	679·87	193·48	769·29	11
12	1 in 440	154·76	120·30	174·39	202·33	219·34	617·63	221·99	710·10	202·08	803·50	12
13	1 in 406	161·08	125·21	181·51	210·60	228·30	642·85	231·06	739·10	210·33	836·31	13
14	1 in 377	167·16	129·94	188·36	218·55	236·92	667·12	239·78	767·00	218·27	867·88	14
15	1 in 352	173·03	134·50	194·98	226·22	245·23	690·53	248·19	793·92	225·94	898·34	15
16	1 in 330	178·70	138·91	201·37	233·64	253·27	713·18	256·33	819·95	233·35	927·80	16
17	1 in 311	184·20	143·19	207·57	240·83	261·07	735·13	264·22	845·19	240·53	956·35	17
18	1 in 293	189·54	147·34	213·58	247·81	268·64	756·44	271·88	869·69	247·50	984·08	18
19	1 in 278	194·74	151·37	219·44	254·60	276·00	777·17	279·33	893·52	254·28	1011·05	19
20	1 in 264	199·80	155·31	225·14	261·21	283·17	797·36	286·59	916·74	260·89	1037·31	20
21	1 in 251	204·73	159·14	230·70	267·66	290·16	817·05	293·67	939·37	267·33	1062·98	21
22	1 in 240	209·55	162·89	236·13	273·96	296·99	836·28	300·58	961·48	273·62	1087·94	22
23	1 in 230	214·26	166·55	241·43	280·12	303·66	855·07	307·33	983·09	279·77	1112·39	23
24	1 in 220	218·87	170·13	246·63	286·14	310·20	873·46	313·94	1004·23	285·79	1136·32	24
25	1 in 211	223·38	173·64	251·71	292·04	316·59	891·47	320·42	1024·94	291·68	1159·75	25

VELOCITY AND DISCHARGE IN FEET PER MINUTE OF A CIRCULAR SEWER 26″ IN DIAMETER, WHEN FLOWING ONE-QUARTER, ONE-THIRD, TWO-THIRDS, THREE-FOURTHS THE VERTICAL HEIGHT, AND FULL, WITH A FALL OF ONE TO TWENTY-FIVE FEET PER MILE.

Fall in feet per mile.	Gradient.	One-fourth Vertical Height.		One-third Vertical Height.		Two-thirds Vertical Height.		Three-fourths Vertical Height.		Full.		Fall in feet per mile.
		Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	
1	1 in 5280	43·84	31·60	49·40	53·15	61·67	161·30	62·89	186·53	57·24	211·06	1
2	1 in 2640	62·00	44·69	69·86	75·17	87·36	228·12	88·93	263·80	80·96	298·49	2
3	1 in 1760	75·93	54·73	85·57	92·06	107·00	279·38	108·92	323·08	99·15	365·58	3
4	1 in 1320	87·68	63·20	98·80	106·30	123·55	322·61	125·77	373·06	114·49	422·13	4
5	1 in 1056	98·03	70·66	110·46	118·85	138·13	360·68	140·62	417·10	128·01	471·96	5
6	1 in 880	107·39	77·41	121·01	130·19	151·32	395·11	154·04	456·91	140·22	517·00	6
7	1 in 754	115·99	83·61	130·70	140·62	163·44	426·76	166·38	493·52	151·46	558·43	7
8	1 in 660	124·00	89·38	139·73	150·33	174·72	456·23	177·87	527·59	161·92	596·98	8
9	1 in 586	131·52	94·80	148·20	159·45	185·32	483·91	188·66	559·60	171·74	633·20	9
10	1 in 528	138·64	99·93	156·22	168·08	195·35	510·09	198·86	589·87	181·03	667·45	10
11	1 in 480	145·40	104·81	163·85	176·28	204·88	534·98	208·57	618·66	189·86	700·03	11
12	1 in 440	151·87	109·47	171·13	184·12	213·99	558·77	217·84	646·17	198·31	731·15	12
13	1 in 406	158·07	113·94	178·12	191·63	222·73	581·58	226·74	672·55	206·40	761·01	13
14	1 in 377	164·04	118·24	184·84	198·87	231·14	603·54	235·30	697·94	214·19	789·74	14
15	1 in 352	169·79	122·39	191·33	205·85	239·25	624·72	243·56	722·44	221·71	817·46	15
16	1 in 330	175·36	126·40	197·61	212·60	247·10	645·21	251·54	746·13	228·98	844·26	16
17	1 in 311	180·76	130·29	203·69	219·14	254·70	665·07	259·28	769·09	236·03	870·25	17
18	1 in 293	186·00	134·07	209·59	225·50	262·09	684·35	266·80	791·39	242·88	895·48	18
19	1 in 278	191·10	137·75	215·34	231·68	269·27	703·10	274·11	813·08	249·53	920·02	19
20	1 in 264	196·06	141·32	220·93	237·69	276·26	721·37	281·23	834·20	256·01	943·92	20
21	1 in 251	200·90	144·81	226·38	243·56	283·09	739·18	288·18	854·80	262·34	967·23	21
22	1 in 240	205·63	148·22	231·71	249·30	289·75	756·57	294·96	874·92	268·51	989·99	22
23	1 in 230	210·25	151·55	236·92	254·90	296·26	773·58	301·59	894·58	274·54	1012·23	23
24	1 in 220	214·78	154·81	242·02	260·38	302·63	790·22	308·08	913·82	280·45	1034·01	24
25	1 in 211	219·20	158·01	247·01	265·75	308·88	806·51	314·43	932·66	286·23	1055·33	25

VELOCITY AND DISCHARGE IN FEET PER MINUTE OF A CIRCULAR SEWER 24" IN DIAMETER, WHEN FLOWING ONE-QUARTER, ONE-THIRD, TWO-THIRDS, THREE-FOURTHS THE VERTICAL HEIGHT, AND FULL, WITH A FALL OF ONE TO TWENTY-FIVE FEET PER MILE.

Fall in feet per mile.	Gradient.	One-fourth Vertical Height.		One-third Vertical Height.		Two-thirds Vertical Height.		Three-fourths Vertical Height.		Full.		Fall in feet per mile.
		Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	
1	1 in 5280	42·12	25·87	47·46	43·51	59·35	132·05	60·42	152·70	55·00	172·79	1
2	1 in 2640	59·57	36·59	67·12	61·53	83·94	186·74	85·45	215·95	77·78	244·36	2
3	1 in 1760	72·96	44·81	82·21	75·36	102·80	228·71	104·65	264·49	95·26	299·28	3
4	1 in 1320	84·24	51·74	94·93	87·02	118·70	264·10	120·84	305·41	110·00	345·58	4
5	1 in 1056	94·19	57·85	106·13	97·29	132·71	295·27	135·10	341·46	122·98	386·36	5
6	1 in 880	103·17	63·37	116·26	106·58	145·38	323·45	147·99	374·05	134·72	423·24	6
7	1 in 754	111·44	68·45	125·58	115·12	157·03	349·37	159·85	404·02	145·52	457·16	7
8	1 in 660	119·14	73·17	134·25	123·07	167·87	373·49	170·89	431·91	155·56	488·72	8
9	1 in 586	126·36	77·61	142·39	130·53	178·05	396·15	181·26	458·11	165·00	518·37	9
10	1 in 528	133·20	81·81	150·09	137·59	187·68	417·57	191·06	482·89	173·93	546·40	10
11	1 in 480	139·71	85·80	157·42	144·31	196·84	437·95	200·39	506·46	182·42	573·07	11
12	1 in 440	145·91	89·62	164·42	150·73	205·60	457·43	209·30	528·98	190·53	598·56	12
13	1 in 406	151·87	93·28	171·13	156·88	213·99	476·11	217·84	550·58	198·31	623·00	13
14	1 in 377	157·60	96·80	177·59	162·80	222·07	494·08	226·07	571·36	205·79	646·51	14
15	1 in 352	163·13	100·19	183·82	168·52	229·87	511·42	234·00	591·42	213·01	669·21	15
16	1 in 330	168·48	103·48	189·85	174·04	237·40	528·19	241·67	610·81	220·00	691·15	16
17	1 in 311	173·67	106·66	195·70	179·40	244·71	544·45	249·11	629·61	226·77	712·42	17
18	1 in 293	178·70	109·76	201·37	184·60	251·81	560·23	256·34	647·87	233·35	733·08	18
19	1 in 278	183·60	112·76	206·89	189·66	258·71	575·58	263·36	665·62	239·74	753·17	19
20	1 in 264	188·37	115·69	212·26	194·59	265·43	590·54	270·20	682·91	245·97	772·73	20
21	1 in 251	193·02	118·55	217·50	199·39	271·98	605·12	276·87	699·78	252·04	791·82	21
22	1 in 240	197·56	121·34	222·62	204·08	278·38	619·36	283·39	716·24	257·97	810·45	22
23	1 in 230	202·00	124·07	227·63	208·67	284·64	633·28	289·76	732·34	263·77	828·66	23
24	1 in 220	206·35	126·74	232·52	213·16	290·76	646·90	295·99	748·09	269·44	846·49	24
25	1 in 211	210·60	129·35	237·32	217·55	296·76	660·24	302·09	763·52	275·00	863·94	25

VELOCITY AND DISCHARGE IN FEET PER MINUTE OF A CIRCULAR SEWER 21" IN DIAMETER, WHEN FLOWING ONE-QUARTER, ONE-THIRD, TWO-THIRDS, THREE-FOURTHS THE VERTICAL HEIGHT, AND FULL, WITH A FALL OF ONE TO TWENTY-FIVE FEET PER MILE.

Fall in feet per mile.	Gradient.	One-fourth Vertical Height.		One-third Vertical Height.		Two-thirds Vertical Height.		Three-fourths Vertical Height.		Full.		Fall in feet per mile.
		Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	
1	1 in 5280	39·40	18·53	44·40	31·16	55·52	94·57	56·52	109·36	51·44	123·75	1
2	1 in 2640	55·72	26·20	62·79	44·07	78·51	133·74	79·93	154·66	72·75	175·00	2
3	1 in 1760	68·24	32·09	76·90	53·97	96·16	163·80	97·89	189·42	89·11	214·34	3
4	1 in 1320	78·80	37·05	88·80	62·32	111·04	189·14	113·03	218·72	102·90	247·50	4
5	1 in 1056	88·10	41·43	99·28	69·68	124·14	211·47	126·37	244·54	115·04	276·71	5
6	1 in 880	96·51	45·38	108·75	76·33	135·99	231·65	138·44	267·88	126·02	303·11	6
7	1 in 754	104·24	49·02	117·46	82·45	146·89	250·21	149·53	289·34	136·12	327·40	7
8	1 in 660	111·44	52·40	125·57	88·14	157·03	267·48	159·85	309·32	145·52	350·02	8
9	1 in 586	118·19	55·58	133·20	93·48	166·55	283·71	169·55	328·09	154·34	371·24	9
10	1 in 528	124·60	58·59	140·40	98·54	175·56	299·06	178·72	345·83	162·69	391·32	10
11	1 in 480	130·68	61·45	147·25	103·35	184·13	313·65	187·44	362·71	170·63	410·43	11
12	1 in 440	136·49	64·18	153·80	107·94	192·32	327·60	195·78	378·84	178·22	428·67	12
13	1 in 406	142·06	66·80	160·08	112·35	200·17	340·98	203·77	394·31	185·50	446·18	13
14	1 in 377	147·42	69·32	166·12	116·59	207·73	353·85	211·47	409·20	192·50	463·02	14
15	1 in 352	152·60	71·76	171·95	120·69	215·02	366·27	218·89	423·56	199·26	479·27	15
16	1 in 330	157·60	74·11	177·59	124·65	227·07	378·28	226·07	437·45	205·79	494·99	16
17	1 in 311	162·45	76·39	183·06	128·48	228·91	389·92	233·02	450·91	212·12	510·22	17
18	1 in 293	167·16	78·61	188·36	132·21	235·54	401·23	239·78	463·98	218·27	525·01	18
19	1 in 278	171·74	80·76	193·53	135·83	242·00	412·22	246·35	476·70	224·26	539·40	19
20	1 in 264	176·20	82·86	198·55	139·36	248·28	422·93	252·75	489·08	230·08	553·41	20
21	1 in 251	180·55	84·90	203·46	142·80	254·41	433·38	258·99	501·16	235·76	567·08	21
22	1 in 240	184·80	86·90	208·24	146·16	260·40	443·57	265·09	512·95	241·31	580·42	22
23	1 in 230	188·96	88·85	212·92	149·45	266·26	453·55	271·04	524·48	246·74	593·47	23
24	1 in 220	193·02	90·77	217·50	152·66	271·98	463·30	276·87	535·76	252·04	606·23	24
25	1 in 211	197·00	92·64	221·99	155·81	277·60	472·87	282·58	546·81	257·24	618·73	25

VELOCITY AND DISCHARGE IN FEET PER MINUTE OF A CIRCULAR SEWER 18″ IN DIAMETER, WHEN FLOWING ONE-QUARTER, ONE-THIRD, TWO-THIRDS, THREE-FOURTHS THE VERTICAL HEIGHT, AND FULL, WITH A FALL OF ONE TO TWENTY-FIVE FEET PER MILE.

Fall in feet per mile.	Gradient.	One-fourth Vertical Height.		One-third Vertical Height.		Two-thirds Vertical Height.		Three-fourths Vertical Height.		Full.		Fall in feet per mile.
		Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	
1	1 in 5280	36·48	12·60	41·10	21·20	51·40	64·33	52·32	74·39	47·63	84·17	1
2	1 in 2640	51·58	17·82	58·13	29·98	72·69	90·97	74·00	105·20	67·36	119·04	2
3	1 in 1760	63·18	21·83	71·19	36·71	89·02	111·42	90·63	128·84	82·50	145·79	3
4	1 in 1320	72·96	25·20	82·21	42·39	102·80	128·65	104·65	148·78	95·26	168·34	4
5	1 in 1056	81·57	28·18	91·91	47·40	114·93	143·84	117·00	166·34	106·51	188·21	5
6	1 in 880	89·35	30·87	100·68	51·92	125·90	157·57	128·17	182·21	116·67	206·18	6
7	1 in 754	96·51	33·34	108·75	56·08	135·96	170·15	138·44	196·81	126·02	222·70	7
8	1 in 660	103·17	35·64	116·26	59·95	145·35	181·90	147·99	210·40	134·72	238·07	8
9	1 in 586	109·43	37·81	123·31	63·59	154·20	192·98	156·97	223·16	142·89	252·52	9
10	1 in 528	115·35	39·85	129·98	67·03	162·54	203·42	165·46	235·23	150·62	266·17	10
11	1 in 480	120·98	41·80	136·33	70·30	170·47	213·35	173·54	246·72	157·98	279·17	11
12	1 in 440	126·36	43·66	142·39	73·42	178·05	222·83	181·26	257·69	165·00	291·58	12
13	1 in 406	131·52	45·44	148·20	76·42	185·32	231·93	188·66	268·21	171·74	303·49	13
14	1 in 377	136·49	47·15	153·80	79·31	192·32	240·69	195·78	278·33	178·22	314·94	14
15	1 in 352	141·28	48·81	159·20	82·09	199·07	249·13	202·65	288·10	184·48	326·00	15
16	1 in 330	145·91	50·41	164·42	84·78	205·60	257·30	209·30	297·55	190·53	336·69	16
17	1 in 311	150·40	51·96	169·48	87·39	211·93	265·22	215·74	306·71	196·39	347·05	17
18	1 in 293	154·76	53·47	174·39	89·93	218·07	272·91	221·99	315·60	202·08	357·11	18
19	1 in 278	159·00	54·93	179·17	92·39	224·05	280·39	228·08	324·25	207·62	366·90	19
20	1 in 264	163·13	56·36	183·83	94·79	229·87	287·68	234·00	332·67	213·01	376·43	20
21	1 in 251	167·16	57·75	188·36	97·13	235·54	294·78	239·78	340·89	218·27	385·72	21
22	1 in 240	171·10	59·11	192·80	99·44	241·09	301·72	245·42	348·91	223·41	394·80	22
23	1 in 230	174·94	60·44	197·13	101·65	246·50	308·50	250·94	356·75	228·43	403·67	23
24	1 in 220	178·70	61·74	201·37	103·84	251·81	315·13	256·33	364·42	233·35	412·36	24
25	1 in 211	182·39	63·01	205·52	105·98	257·00	321·63	261·62	371·94	238·16	420·86	25

VELOCITY AND DISCHARGE IN FEET PER MINUTE OF A CIRCULAR SEWER 15" IN DIAMETER, WHEN FLOWING ONE-QUARTER, ONE-THIRD, TWO-THIRDS, THREE-FOURTHS THE VERTICAL HEIGHT, AND FULL, WITH A FALL OF ONE TO TWENTY-FIVE FEET PER MILE.

Fall in feet per mile.	Gradient.	One-fourth Vertical Height.		One-third Vertical Height.		Two-thirds Vertical Height.		Three-fourths Vertical Height.		Full.		Fall in feet per mile.
		Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	
1	1 in 5280	33·30	7·98	37·52	13·44	46·92	40·78	47·76	47·16	43·48	53·36	1
2	1 in 2640	47·09	11·30	53·07	19·00	66·36	57·67	67·55	66·69	61·49	75·46	2
3	1 in 1760	57·68	13·84	64·99	23·27	81·27	70·63	82·73	81·68	75·31	92·42	3
4	1 in 1320	66·60	15·98	75·05	26·87	93·84	81·56	95·53	94·31	86·96	106·72	4
5	1 in 1056	74·46	17·86	83·90	30·05	104·92	91·18	106·81	105·44	97·23	119·32	5
6	1 in 880	81·57	19·57	91·91	32·91	114·93	99·89	117·00	115·51	106·51	130·70	6
7	1 in 754	88·10	21·14	99·28	35·55	124·14	107·89	126·37	124·76	115·04	141·18	7
8	1 in 660	94·19	22·60	106·13	38·01	132·71	115·34	135·10	133·38	122·98	150·92	8
9	1 in 586	99·90	23·97	112·57	40·31	140·76	122·34	143·29	141·47	130·44	160·08	9
10	1 in 528	105·30	25·26	118·66	42·49	148·38	128·95	151·05	149·12	137·50	168·74	10
11	1 in 480	110·44	26·50	124·45	44·56	155·62	135·25	158·42	156·40	144·21	176·97	11
12	1 in 440	115·35	27·67	129·97	46·54	162·54	141·26	165·46	163·35	150·62	184·84	12
13	1 in 406	120·06	28·80	135·29	48·45	169·18	147·03	172·22	170·02	156·77	192·39	13
14	1 in 377	124·60	29·89	140·40	50·28	175·56	152·58	178·72	176·44	162·69	199·65	14
15	1 in 352	128·97	30·94	145·33	52·04	181·72	157·94	184·99	182·64	168·40	206·66	15
16	1 in 330	133·20	31·96	150·09	53·75	187·68	163·11	191·06	188·63	173·93	213·44	16
17	1 in 311	137·30	32·94	154·71	55·40	193·46	168·13	196·94	194·43	179·28	220·02	17
18	1 in 293	141·28	33·89	159·20	57·01	199·07	173·01	202·65	200·07	184·48	226·39	18
19	1 in 278	145·15	34·82	163·56	58·57	204·52	177·75	208·20	205·55	189·53	232·59	19
20	1 in 264	148·92	35·73	167·81	60·09	209·84	182·36	213·61	210·89	194·45	238·63	20
21	1 in 251	152·60	36·61	171·95	61·58	215·02	186·87	218·89	216·10	199·26	244·52	21
22	1 in 240	156·19	37·47	176·00	63·02	220·08	191·27	224·04	221·18	203·95	250·28	22
23	1 in 230	159·70	38·31	179·95	64·44	225·03	195·57	229·07	226·15	208·53	255·90	23
24	1 in 220	163·13	39·14	183·82	65·83	229·87	199·77	234·00	231·02	213·01	261·01	24
25	1 in 211	166·50	39·95	187·61	67·18	234·61	203·89	238·82	235·78	217·41	266·80	25

VELOCITY AND DISCHARGE IN FEET PER MINUTE OF A CIRCULAR SEWER 14" IN DIAMETER, WHEN FLOWING ONE-QUARTER, ONE-THIRD, TWO-THIRDS, THREE-FOURTHS THE VERTICAL HEIGHT, AND FULL, WITH A FALL OF ONE TO TWENTY-FIVE FEET PER MILE.

Fall in feet per mile.	Gradient.	One-fourth Vertical Height.		One-third Vertical Height.		Two-thirds Vertical Height.		Three-fourths Vertical Height.		Full.		Fall in feet per mile.
		Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	
1	1 in 5280	32·17	6·72	36·25	11·31	45·33	34·32	46·15	39·69	42·01	44·91	1
2	1 in 2640	45·50	9·50	51·27	15·99	64·11	48·53	65·26	56·13	59·41	63·51	2
3	1 in 1760	55·72	11·65	62·79	19·59	78·51	59·44	79·93	68·74	72·76	77·78	3
4	1 in 1320	64·34	13·45	72·50	22·62	90·66	68·64	92·29	79·37	84·01	89·81	4
5	1 in 1056	71·94	15·03	81·06	25·29	101·36	76·74	103·18	88·74	93·93	100·41	5
6	1 in 880	78·80	16·47	88·80	27·70	111·04	84·06	113·03	97·21	102·90	110·00	6
7	1 in 754	85·11	17·79	95·91	29·92	119·93	90·80	122·09	105·00	111·14	118·81	7
8	1 in 660	90·99	19·02	102·53	31·98	128·21	97·07	130·52	112·25	118·81	127·01	8
9	1 in 586	96·51	20·17	108·75	33·92	135·99	102·96	138·44	119·06	126·02	134·72	9
10	1 in 528	101·73	21·26	114·63	35·76	143·35	108·52	145·93	125·50	132·84	142·01	10
11	1 in 480	106·70	22·30	120·23	37·50	150·34	113·82	153·05	131·63	139·32	148·94	11
12	1 in 440	111·44	23·29	125·58	39·17	157·03	118·88	159·85	137·48	145·52	155·56	12
13	1 in 406	115·99	24·24	130·70	40·77	163·44	123·74	166·38	143·09	151·46	161·91	13
14	1 in 377	120·37	25·16	135·64	42·31	169·61	128·41	172·66	148·49	157·18	168·02	14
15	1 in 352	124·60	26·04	140·40	43·80	175·56	132·92	178·72	153·71	162·69	173·92	15
16	1 in 330	128·68	26·89	145·00	45·23	181·32	137·27	184·58	158·75	168·03	179·62	16
17	1 in 311	132·64	27·72	149·47	46·62	186·90	141·50	190·26	163·63	173·20	185·15	17
18	1 in 293	136·49	28·52	153·80	47·98	192·32	145·60	195·78	168·38	178·22	190·52	18
19	1 in 278	140·23	29·31	158·01	49·29	197·59	149·59	201·14	172·99	183·10	195·74	19
20	1 in 264	143·87	30·07	162·12	50·57	202·72	153·48	206·37	177·48	187·86	200·83	20
21	1 in 251	147·42	30·82	166·12	51·82	207·73	157·27	211·47	181·87	192·50	205·79	21
22	1 in 240	150·89	31·54	170·03	53·04	212·62	160·97	216·44	186·15	197·03	210·63	22
23	1 in 230	154·28	32·24	173·85	54·23	217·40	164·59	221·31	190·33	201·46	215·36	23
24	1 in 220	157·60	32·94	177·59	55·40	222·07	168·13	226·07	194·42	205·79	219·99	24
25	1 in 211	160·85	33·62	181·25	56·54	226·65	171·59	230·73	198·43	210·03	224·53	25

VELOCITY AND DISCHARGE IN FEET PER MINUTE OF A CIRCULAR SEWER 12" IN DIAMETER, WHEN FLOWING ONE-QUARTER, ONE-THIRD, TWO-THIRDS, THREE-FOURTHS THE VERTICAL HEIGHT, AND FULL, WITH A FALL OF ONE TO TWENTY-FIVE FEET PER MILE.

Fall in feet per mile.	Gradient.	One-fourth Vertical Height.		One-third Vertical Height.		Two-thirds Vertical Height.		Three-fourths Vertical Height.		Full.		Fall in feet per mile.
		Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	
1	1 in 5280	29·78	4·57	33·56	7·69	41·97	23·34	42·72	26·99	38·89	30·54	1
2	1 in 2640	42·12	6·46	47·46	10·88	59·35	33·01	60·42	38·17	55·00	43·20	2
3	1 in 1760	51·59	7·92	58·13	13·33	72·69	40·43	74·00	46·76	67·36	52·90	3
4	1 in 1320	59·57	9·14	67·12	15·38	83·94	46·69	85·45	53·99	77·78	61·09	4
5	1 in 1056	66·60	10·23	75·05	17·20	93·84	52·20	95·53	60·36	86·96	68·30	5
6	1 in 880	72·96	11·20	82·21	18·84	102·80	57·18	104·65	66·12	95·26	74·81	6
7	1 in 754	78·80	12·10	88·80	20·35	111·04	61·76	113·03	71·42	102·89	80·81	7
8	1 in 660	84·24	12·93	94·93	21·76	118·70	66·02	120·84	76·35	110·00	86·39	8
9	1 in 586	89·35	13·72	100·68	23·08	125·90	70·03	128·17	80·98	116·67	91·63	9
10	1 in 528	94·19	14·46	106·13	24·32	132·71	73·82	135·10	85·36	122·98	96·59	10
11	1 in 480	98·78	15·17	111·31	25·51	139·19	77·42	141·69	89·53	128·99	101·31	11
12	1 in 440	103·17	15·84	116·26	26·64	145·38	80·86	148·00	93·51	134·72	105·81	12
13	1 in 406	107·39	16·49	121·01	27·73	151·32	84·16	154·04	97·33	140·22	110·13	13
14	1 in 377	111·44	17·11	125·58	28·78	157·03	87·34	159·85	101·00	145·52	114·32	14
15	1 in 352	115·35	17·72	129·98	29·79	162·54	90·41	165·46	104·55	150·63	118·30	15
16	1 in 330	119·14	18·29	134·25	30·77	167·87	93·37	170·89	107·98	155·56	122·18	16
17	1 in 311	122·80	18·86	138·38	31·71	173·04	96·25	176·15	111·30	160·35	125·94	17
18	1 in 293	126·36	19·40	142·39	32·63	178·05	99·04	181·26	114·53	165·00	129·59	18
19	1 in 278	129·82	19·93	146·29	33·53	182·93	101·75	186·22	117·67	169·52	133·14	19
20	1 in 264	133·20	20·45	150·09	34·40	187·68	104·39	191·06	120·72	173·93	136·60	20
21	1 in 251	136·49	20·96	153·80	35·25	192·32	106·97	195·78	123·71	178·22	139·97	21
22	1 in 240	139·70	21·45	157·42	36·08	196·85	109·49	200·39	126·61	182·41	143·27	22
23	1 in 230	142·84	21·93	160·96	36·89	201·27	111·95	204·89	129·46	186·51	146·49	23
24	1 in 220	145·91	22·40	164·42	37·68	205·60	114·36	209·30	132·24	190·53	149·64	24
25	1 in 211	148·92	22·87	167·81	38·46	209·84	116·71	213·61	134·97	194·45	152·72	25

VELOCITY AND DISCHARGE IN FEET PER MINUTE OF A CIRCULAR SEWER 10″ IN DIAMETER, WHEN FLOWING ONE-QUARTER, ONE-THIRD, TWO-THIRDS, THREE-FOURTHS THE VERTICAL HEIGHT, AND FULL, WITH A FALL OF FIVE TO TWENTY-EIGHT FEET PER MILE.

Fall in feet per mile.	Gradient.	One-fourth Vertical Height.		One-third Vertical Height.		Two-thirds Vertical Height.		Three-fourths Vertical Height.		Full.		Fall in feet per mile.
		Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	
1	1 in 5280	27·19	2·89	30·64	4·87	38·31	14·80	39·00	17·11	35·50	19·36	1
5	1 in 1056	60·80	6·48	68·51	10·90	85·67	33·09	87·21	38·27	79·39	43·30	5
6	1 in 880	66·60	7·10	75·05	11·94	93·84	36·25	95·53	41·92	86·96	47·43	6
7	1 in 754	71·94	7·67	81·06	12·90	101·36	39·15	103·18	45·28	93·93	51·23	7
8	1 in 660	76·90	8·20	86·66	13·79	108·36	41·86	110·31	48·40	100·42	54·77	8
9	1 in 586	81·57	8·69	91·91	14·63	114·93	44·40	117·00	51·34	106·51	58·09	9
10	1 in 528	85·98	9·16	96·88	15·42	121·15	46·80	123·33	54·12	112·27	61·23	10
11	1 in 480	90·18	9·61	101·61	16·17	127·06	49·08	129·35	56·76	117·75	64·22	11
12	1 in 440	94·19	10·04	106·13	16·89	132·71	51·26	135·10	59·28	122·98	67·08	12
13	1 in 406	98·03	10·45	110·46	17·58	138·13	53·36	140·62	61·70	128·01	69·82	13
14	1 in 377	101·73	10·85	114·63	18·24	143·35	55·37	145·92	64·03	132·84	72·45	14
15	1 in 352	105·30	11·23	118·66	18·88	148·38	57·31	151·05	66·28	137·50	74·99	15
16	1 in 330	108·76	11·60	122·55	19·50	153·24	59·19	156·00	68·45	142·01	77·45	16
17	1 in 311	112·10	11·95	126·32	20·10	157·96	61·02	160·80	70·56	146·38	79·84	17
18	1 in 293	115·35	12·30	129·98	20·69	162·54	62·78	165·46	72·60	150·62	82·15	18
19	1 in 278	118·51	12·64	133·55	21·25	166·99	64·50	170·00	74·59	154·75	84·40	19
20	1 in 264	121·59	12·97	137·01	21·81	171·33	66·18	174·41	76·53	158·77	86·60	20
21	1 in 251	124·60	13·29	140·40	22·34	175·56	67·81	178·72	78·42	162·69	88·73	21
22	1 in 240	127·53	13·60	143·70	22·87	179·69	69·41	182·93	80·27	166·52	90·82	22
23	1 in 230	130·39	13·90	146·93	23·38	183·73	70·97	187·04	82·07	170·26	92·86	23
24	1 in 220	133·20	14·20	150·09	23·89	187·68	72·50	191·06	83·83	173·93	94·86	24
25	1 in 211	135·94	14·50	153·19	24·38	191·55	73·99	195·00	85·56	177·51	96·82	25
26	1 in 203	138·64	14·78	156·22	24·86	195·35	75·46	198·86	87·26	181·03	98·74	26
27	1 in 196	141·28	15·06	159·20	25·34	199·07	76·89	202·65	88·92	184·48	100·62	27
28	1 in 188	143·87	15·34	162·12	25·80	202·72	78·31	206·37	90·55	187·86	102·46	28

VELOCITY AND DISCHARGE IN FEET PER MINUTE OF A CIRCULAR SEWER 9" IN DIAMETER, WHEN FLOWING ONE-QUARTER, ONE-THIRD, TWO-THIRDS, THREE-FOURTHS THE VERTICAL HEIGHT, AND FULL, WITH A FALL OF TEN TO THIRTY-THREE FEET PER MILE.

Fall in feet per mile.	Gradient.	One-fourth Vertical Height.		One-third Vertical Height.		Two-thirds Vertical Height.		Three-fourths Vertical Height.		Full.		Fall in feet per mile.
		Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	
1	1 in 5280	25·79	2·23	29·07	3·75	36·34	11·37	37·00	13·15	33·68	14·88	1
10	1 in 528	81·57	7·04	91·91	11·85	114·93	35·96	117·00	41·58	106·51	47·05	10
11	1 in 480	85·55	7·39	96·40	12·43	120·54	37·72	122·71	43·61	111·71	49·35	11
12	1 in 440	89·35	7·72	100·68	12·98	125·90	39·39	128·17	45·55	116·67	51·54	12
13	1 in 406	93·00	8·03	104·80	13·51	131·04	41·00	133·40	47·41	121·44	53·65	13
14	1 in 377	96·51	8·34	108·75	14·02	135·99	42·55	138·44	49·20	126·02	55·67	14
15	1 in 352	99·90	8·63	112·57	14·51	140·76	44·04	143·30	50·93	130·44	57·63	15
16	1 in 330	103·17	8·91	116·26	14·99	145·38	45·49	147·99	52·60	134·72	59·52	16
17	1 in 311	106·35	9·18	119·84	15·45	149·85	46·89	152·55	54·22	138·87	61·35	17
18	1 in 293	109·43	9·45	123·31	15·90	154·20	48·25	156·97	55·79	142·89	63·13	18
19	1 in 278	112·43	9·71	126·69	16·33	158·42	49·57	161·27	57·32	146·81	64·86	19
20	1 in 264	115·35	9·96	129·98	16·76	162·54	50·86	165·46	58·81	150·62	66·54	20
21	1 in 251	118·20	10·21	133·19	17·17	166·55	52·11	169·55	60·26	154·34	68·19	21
22	1 in 240	120·98	10·45	136·33	17·57	170·47	53·34	173·54	61·68	157·98	69·79	22
23	1 in 230	123·70	10·68	139·39	17·97	174·30	54·54	177·44	63·07	161·53	71·36	23
24	1 in 220	126·36	10·91	142·39	18·36	178·05	55·71	181·26	64·42	165·00	72·89	24
25	1 in 211	128·97	11·14	145·33	18·73	181·72	56·86	184·99	65·75	168·40	74·40	25
26	1 in 203	131·52	11·36	148·20	19·11	185·32	57·98	188·66	67·05	171·74	75·87	26
27	1 in 196	134·03	11·58	151·03	19·47	188·85	59·09	192·25	68·33	175·01	77·32	27
28	1 in 189	136·49	11·79	153·80	19·83	192·32	60·17	195·78	69·58	178·22	78·74	28
29	1 in 182	138·90	12·00	156·52	20·18	195·72	61·24	199·24	70·81	181·37	80·13	29
30	1 in 176	141·28	12·20	159·20	20·52	199·07	62·28	202·65	72·03	184·48	81·50	30
31	1 in 170	143·61	12·40	161·83	20·86	202·36	63·31	206·00	73·22	187·52	82·85	31
32	1 in 165	145·91	12·60	164·42	21·20	205·60	64·33	209·30	74·39	190·53	84·17	32
33	1 in 160	148·17	12·80	166·97	21·52	208·79	65·32	212·54	75·54	193·48	85·48	33

VELOCITY AND DISCHARGE IN FEET PER MINUTE OF A CIRCULAR SEWER 8" IN DIAMETER, WHEN FLOWING ONE-QUARTER, ONE-THIRD, TWO-THIRDS, THREE-FOURTHS THE VERTICAL HEIGHT, AND FULL, WITH A FALL OF FIFTEEN TO THIRTY-EIGHT FEET PER MILE.

Fall in feet per mile.	Gradient.	One-fourth Vertical Height.		One-third Vertical Height.		Two-thirds Vertical Height.		Three-fourths Vertical Height.		Full.		Fall in feet per mile.
		Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	
1	1 in 5280	24·32	1·65	27·40	2·79	34·27	8·47	34·88	9·79	31·75	11·08	1
15	1 in 352	94·19	6·43	106·13	10·81	132·71	32·81	135·10	37·94	122·98	42·93	15
16	1 in 330	97·27	6·64	109·61	11·16	137·07	33·88	139·53	39·18	127·02	44·34	16
17	1 in 311	100·27	6·84	112·98	11·51	141·28	34·93	143·83	40·39	130·93	45·70	17
18	1 in 293	103·17	7·04	116·26	11·84	145·38	35·94	148·00	41·56	134·72	47·03	18
19	1 in 278	106·00	7·23	119·45	12·17	149·36	36·92	152·05	42·70	138·41	48·32	19
20	1 in 264	108·76	7·42	122·55	12·48	153·24	37·88	156·00	43·81	142·01	49·57	20
21	1 in 251	111·44	7·60	125·58	12·79	157·03	38·82	159·85	44·89	145·52	50·79	21
22	1 in 240	114·06	7·78	128·53	13·09	160·72	39·73	163·61	45·95	148·94	51·99	22
23	1 in 230	116·63	7·96	131·42	13·39	164·34	40·63	167·29	46·98	152·29	53·16	23
24	1 in 220	119·14	8·13	134·25	13·67	167·87	41·50	170·89	47·99	155·56	54·30	24
25	1 in 211	121·59	8·30	137·01	13·96	171·33	42·35	174·41	48·98	158·77	55·42	25
26	1 in 203	124·00	8·46	139·73	14·23	174·72	43·19	177·87	49·95	161·92	56·52	26
27	1 in 195	126·36	8·62	142·39	14·50	178·05	44·02	181·26	50·90	165·00	57·60	27
28	1 in 188	128·68	8·78	145·00	14·77	181·32	44·82	184·58	51·84	168·03	58·65	28
29	1 in 182	130·96	8·94	147·57	15·03	184·53	45·62	187·85	52·75	171·00	59·69	29
30	1 in 176	133·20	9·09	150·09	15·29	187·68	46·40	191·06	53·65	173·93	60·71	30
31	1 in 170	135·40	9·24	152·57	15·54	190·79	47·16	194·22	54·54	176·80	61·71	31
32	1 in 165	137·57	9·39	155·01	15·79	193·84	47·92	197·33	55·41	179·63	62·70	32
33	1 in 160	139·70	9·53	157·42	16·03	196·85	48·66	200·39	56·27	182·41	63·67	33
34	1 in 155	141·80	9·68	159·78	16·28	199·81	49·39	203·40	57·12	185·16	64·63	34
35	1 in 151	143·87	9·82	162·12	16·51	202·72	50·11	206·37	57·95	187·86	65·58	35
36	1 in 147	145·91	9·96	164·42	16·75	205·60	50·83	209·30	58·78	190·53	66·51	36
37	1 in 143	147·92	10·09	166·69	16·98	208·43	51·53	212·18	59·59	193·15	67·42	37
38	1 in 139	149·91	10·23	168·92	17·21	211·23	52·22	215·03	60·39	195·75	68·33	38

VELOCITY AND DISCHARGE IN FEET PER MINUTE OF CIRCULAR PIPES 6", 4", AND 3" IN DIAMETER, WHEN FLOWING ONE-QUARTER, ONE-THIRD, TWO-THIRDS, THREE-FOURTHS THE VERTICAL HEIGHT, AND FULL, AT VARIOUS GRADIENTS.

6"

Fall in feet per mile.	Gradient.	One-fourth Vertical Height.		One-third Vertical Height.		Two-thirds Vertical Height.		Three-fourths Vertical Height.		Full.		Fall in feet per mile.
		Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	
1	1 in 5280	21·1	0·81	23·7	1·36	29·7	4·13	30·2	4·77	27·5	5·40	1
10	1 in 528	66·6	2·50	75·0	4·30	93·8	13·0	95·5	15·1	87·0	17·1	10
20	1 in 264	94·1	3·62	106·1	6·08	132·7	18·5	135·1	21·3	122·9	24·1	20
30	1 in 176	115·4	4·43	130·0	7·45	162·5	22·6	165·5	26·1	150·6	29·6	30
40	1 in 132	133·2	5·11	150·1	8·60	187·7	26·1	191·1	30·2	173·9	34·1	40
50	1 in 106	148·9	5·72	167·8	9·62	209·8	29·2	213·6	33·7	194·4	38·2	50
75	1 in 70	182·3	7·00	205·5	11·78	256·9	35·7	261·6	41·3	238·2	46·8	75
100	1 in 53	210·6	8·08	237·3	13·6	296·7	41·3	302·1	47·7	275·0	54·0	100
					4"							
1	1 in 5280	17·2	0·29	19·4	0·49	24·2	1·50	24·7	1·73	22·5	1·96	1
25	1 in 211	86·0	1·47	96·9	2·47	121·1	7·49	123·3	8·66	112·3	9·80	25
50	1 in 106	121·6	2·07	137·0	3·49	171·3	10·6	174·4	12·2	158·8	13·8	50
75	1 in 70	148·9	2·54	167·8	4·27	209·8	13·0	213·6	15·0	194·5	17·0	75
100	1 in 53	172·0	2·93	193·8	4·93	242·3	15·0	246·6	17·3	224·5	19·6	100
150	1 in 35	210·6	3·59	237·3	6·04	296·8	18·3	302·1	21·2	275·0	24·0	150
200	1 in 26	221·8	3·78	274·0	6·97	342·7	21·2	348·8	24·5	317·5	27·7	200
500	1 in 11	384·5	6·56	433·3	11·0	541·8	33·5	551·5	38·7	502·1	43·8	500
					3"							
1	1 in 5280	14·9	0·14	16·8	0·24	21·0	0·73	21·4	0·84	19·5	0·95	1
25	1 in 211	74·5	0·71	83·9	1·20	104·9	3·65	106·8	4·22	97·2	4·77	25
50	1 in 106	105·3	1·01	118·7	1·70	148·4	5·16	151·0	5·96	137·5	6·75	50
75	1 in 70	129·0	1·24	145·3	2·08	181·7	6·32	185·0	7·31	168·4	8·27	75
100	1 in 53	148·9	1·43	167·8	2·40	209·8	7·29	213·6	8·44	194·4	9·55	100
150	1 in 35	182·4	1·75	205·5	2·94	257·0	8·93	261·6	10·3	238·2	11·7	150
200	1 in 26	210·6	2·02	237·3	3·40	296·7	10·3	302·9	11·9	275·0	13·5	200
500	1 in 11	333·0	3·20	375·2	5·37	469·2	16·3	477·7	18·9	434·8	21·3	500

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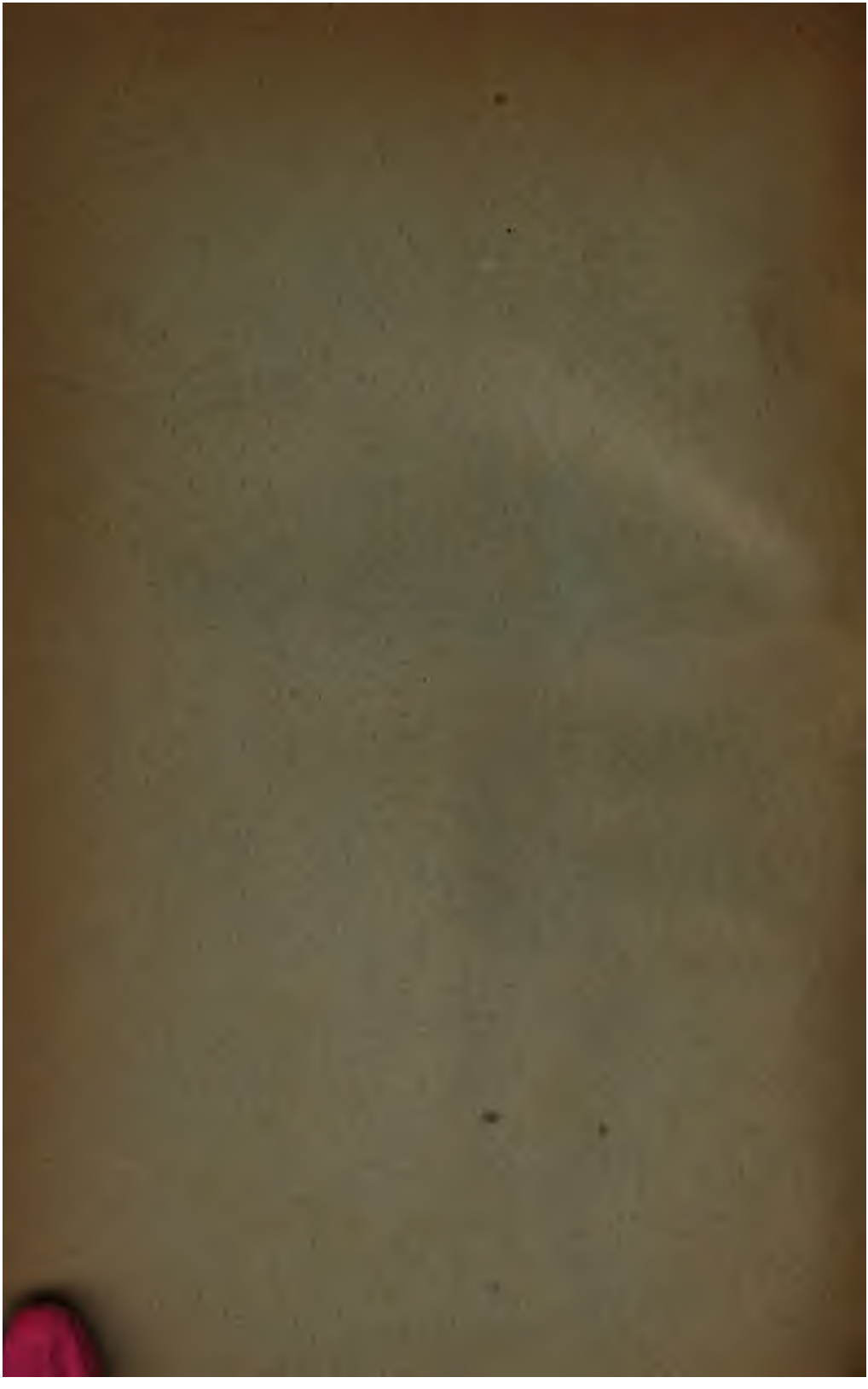

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THE "INTERNATIONAL PROCESS,"

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BY THE

INTERNATIONAL WATER & SEWAGE PURIFICATION COMPANY, LIMITED,

OF

11, QUEEN VICTORIA STREET, LONDON, E.C.,

WITH

THE REPORT OF

SIR HENRY E. ROSCOE, M.P., F.R.S., LL.D., PH.D., &C.,

AND OTHERS, AND

OPINIONS OF THE PRESS

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A PAMPHLET

ON THE

PREVENTION

OF

CHOLERA AND FEVERS

THROUGH THE

PURIFICATION

OF

DRINKING WATER

BY MEANS OF

"POLARITE" (Magnetic Spongy Carbon),

May also be obtained Gratis on Application.

PUBLISHED BY

THE INTERNATIONAL WATER AND SEWAGE

PURIFICATION COMPANY (LIMITED),

11, QUEEN VICTORIA STREET, LONDON, E.C.

A TREATISE

ON THE

INTERNATIONAL SYSTEM OF SEWAGE PURIFICATION,

INCLUDING THE

REPORT OF SIR HENRY ROSCOE, M.P., F.R.S., LL.D., Ph.D.

The International Process for the Purification of Sewage consists—

FIRSTLY, IN EFFECTING PRECIPITATION OF THE SOLIDS, AND DEODORIZATION OF THE SUPERNATANT LIQUID.

SECONDLY, IN THE REMOVAL OF THE ORGANIC MATTER IN SOLUTION AND THE AERATION OF THE TANK EFFLUENT BY PASSING IT THROUGH A SPECIALLY CONSTRUCTED FILTER BED OF MAGNETIC SPONGY CARBON (HEREAFTER CALLED "POLARITE").

THE FIRST PART OF THE PROCESS IS EFFECTED BY THE MAGNETIC PRECIPITANT AND DEODORANT (HEREAFTER CALLED FEROZONE), WHICH IS PRODUCED FROM "POLARITE" BY A CHEMICAL PROCESS.

"FEROZONE" for Sewage Precipitation and Deodorization is rich in ferrous iron, alum, magnesia and magnetic oxide of iron in a very spongy and absorptive condition. By virtue of its soluble iron, alumina and magnesia salts, it rapidly causes subsidence of the solids, and the iron, being porous and magnetic, parts with its polarized oxygen, thereby assisting the disinfection and deodorizing of the sewage and sludge. The sludge precipitated is of considerable value as a fertilizer, lime, which is so highly objectionable, being dispensed with, and the loss of ammonia caused by the "Lime process" entirely avoided.

The value of avoiding lime is plain when one considers that the following statements are incontrovertible.

1st—Lime spoils the effluent by throwing much organic matter into solution.

2nd—Lime spoils the manurial value of the sludge.

3rd—Lime creates an intolerable nuisance, and pollutes the atmosphere by setting free ammoniacal vapours and stinking sulphur compounds.

4th—Lime effluents pollute by secondary decompositions any stream into which they may flow.

5th—Lime effluents are destructive to fish life.

6th—Lime makes an enormous quantity of sludge, both useless and expensive to deal with.

These are the main causes why the treatment of sewage has been attended with so much trouble, but the temptation to employ Lime on account of its *appearing* so cheap has induced many authorities to sanction its use, although it is well known that Lime inevitably causes secondary decompositions of a most dangerous kind, polluting streams into which it passes, and frequently giving rise to ruinous litigation.

The sewage manure obtained by the "International" process contains by analysis nitrogen equivalent to about 2% of ammonia besides phosphates, and is sold in a fine powder at 30s. per ton.

The second part of the process secures the perfection of sewage treatment by causing the effluent from the precipitating tanks to pass through a filter bed of Magnetic Spongy Carbon (Polarite); a recent analysis shows that *as much as* 96 PER CENT. of the *organic matter in solution* had been removed, as well as all suspended matter. In fact, to quote from "*Iron*," when describing this process, "Its success and its economy combine to mark it as a practical departure in the science of sewage disposal, in the history of which it constitutes a new

chapter." *It will filter sewage effluents at the rate of* 1,000 *gallons per square yard per* 24 *hours, with better results than can be obtained by land which filters at about* 1½ *gallons per square yard per* 24 *hours; or, in other words, one acre of filtering area containing a layer of "Polarite" will do more efficient work than* 666 *acres of land.*

The value of this discovery can scarcely be over-estimated, as by the use of these small but powerfully active filter beds, it is entirely unnecessary to acquire large areas of land for expensive Sewage Farms; the Polarite in these beds never requires changing or removing, a slight rest of a few hours occasionally being all that is needed to effect revivification, and a flushing or cleansing of the top surface sand.

The "International" process removes the difficulties hitherto inseparable from sewage purification and sludge disposal.

"Polarite" is the only permanent oxidizer that is sufficiently cheap and durable for practical use on a large scale in filter beds, for the purification of large volumes of sewage effluent.

"Polarite" is a pure and absolutely insoluble mineral substance, specially manufactured for the filtration and purification of water, fluids and gases, *vide* Report of Sir Henry Roscoe. It contains no poisonous metal; is very hard, porous and absorptive. It extracts iron and lead from water, and attacks and destroys organic matters in solution. It is a powerful decolorizer and deodorizer by virtue of the polarized oxygen contained within its microscopic pores, is extremely durable, and magnetic to a remarkable degree; and, notwithstanding that iron is the chief element in its constitution it will not rust, and for this and other reasons is vastly superior to Spongy Iron. It produces remarkable effects in the purification of foul and peaty waters, and renders sewage effluents bright and clear as spring water. Mixed with sand, or small gravel, it forms a practically everlasting filter bed. It supplies

a long-felt want, and can be obtained at a price so moderate as will undoubtedly bring it into general use where a good effluent is required. Liquids treated with it become highly charged with oxygen, and a true process of combustion takes place by contact with the polarized oxygen contained within the microscopic pores of the material, the products of which combustion are tasteless, odourless and colourless, and the water is left sparkling and palatable. This has been proved by an exhaustive series of practical tests.

Abridged Report by SIR HENRY E. ROSCOE, M.P., F.R.S., LL.D., Ph.D., &c. :—

10, Bramham Gardens,
Wetherby Road, S.W.,
August 20th, 1888.

To the Directors of the International
Water and Sewage Purfication Company.

GENTLEMEN,

I have at your request investigated, and now beg to report upon your process for the Purification of Sewage as carried out at Acton.

For this purpose I visited the works at Acton on Monday, July 9th, and found that the water carrying Sewage ran along a channel into which was flowing a turbid solution of your precipitant known as "Magnetic Ferrous Carbon." *

This mixture flows with the raw Sewage into a large precipitating tank of 138,000 gallons capacity. Of these there are three side by side. Subsidence is allowed to take place for a period of from one to three hours, after which the top liquid is run off from the surface by means of a floating arm, direct on to the filter bed, which is made up of sand as a top layer, then a layer of your preparation, known as "Magnetic Spongy Carbon" †, the bottom being made up of coarse gravel.

The names used above are not chemical but commercial designations.

* Ferozone. † Polarite.

I found the resulting filtered effluent to be bright, clear and colourless, and free from any objectionable smell.

Many samples of the tank liquid and the filtered effluent were taken by Mr. Lailey, the Engineer to the Acton Local Board and also by my Assistant, Mr. Joseph Lunt, B.Sc., and these were analysed.

I have always found that the filtered effluent was equal in appearance to the sample taken on the day of my visit, viz., bright, clear, colourless and free from objectionable smell. Many samples of this filtered effluent have been analysed. The average results obtained are given in the following figures:—

Analysis of Filtered Effluents.

	Parts per 100,000.	Grains per Gallon.
Chlorine	6·4	4·48
Free Ammonia	0·406	0·284
Albuminoid do.	0·025	0·018
Oxygen absorbed from permanganate in 4 hours	0·325	0·228

Samples of the effluent have been kept in absence of air for nearly two months, and have still retained their good qualities.

They exhibit no trace of putrefractive change but have rather undergone improvement, inasmuch as in most cases a slight green growth has taken place, showing that the effluent is in a condition to be acted upon by the natural influences which will tend further to improve the water whilst flowing along a stream.

But it is to be observed that the amount of organic matter, as measured by the quantities of the two forms of ammonia, is above the limit of a safe drinking water. Hence whilst the effluent is an excellent Sewage effluent and may be sent into the river at the present outflow without danger, it is obviously unfit for drinking purposes.

I consider the removal of all the suspended matter to be a very good point in favour of the system. Another is the intermittent nature of the filtration.

This is assisted and the filter kept in good order by frequently raking over the surface, removing the surface layer of sand and replacing it by washed and clean material.

The tank effluent before filtration is always turbid, and has a distinct but not very offensive smell, but even this becomes clear on standing. It contains more organic matter than the filtered effluent. Many samples have been analysed, with the following results:—

Analysis of Unfiltered Effluents.

	Parts per 100,000.	Grains per gallon.
Chlorine	6·2	4·34
Free Ammonia	1·1	0·77
Albuminoid do.	0·071	0·050
Oxygen absorbed from permanganate in 4 hours	0·652	0.459

These numbers contrast favourably with a series of analyses made of the raw Sewage, which however I do not quote, as the samples taken from time to time varied greatly in composition.

The porous nature of the oxide, which is used in the filter, its complete insolubility and its freedom from rusting, constitute in my opinion its claim to be considered a valuable filtering material. A sample of this filtering material taken at Acton gives the following results on analysis.

Analysis of "Magnetic Spongy Carbon" (Polarite).

Magnetic Oxide of Iron	53·85
Silica	25·50
Lime	2.01
Alumina	5·68
Magnesia	7·55
Carbonaceous Matters and Moisture	5·41
	100·00

The material called "Magnetic Ferrous Carbon," used for mixing with the Sewage contains mainly Sulphate and Magnetic Oxide of Iron.

A sample taken on the Works at Acton gave the following numbers on analysis:—

Analysis of "Magnetic Ferrous Carbon" (Ferozone).

Soluble Constituents.	Ferrous Sulphate	26·64
	Aluminium Sulphate	2·19
	Calcium Sulphate	3·30
	Magnesium Sulphate	5·17
	Combined Water	8·20
	Moisture	24·14
Insoluble Constituents.	Silica	11·35
	Magnetic Oxide of Iron	19·01
		100·00

The soluble portion of the material, called "Magnetic Ferrous Carbon" when mixed with the alkaline Sewage, forms a slight precipitate, and the insoluble portion (Spongy Magnetic Oxide) assists in the subsidence, and from its porous nature may also act as an absorbent of some of the organic matter.

About 8 grains per gallon of Sewage is added during the flow into the precipitating tank, and after from one to three hours' subsidence the liquid is drawn off. The Sludge remaining is run into a well, whence it is pumped into a press and the pressed cakes dried in a current of hot air from a coke fire. The Sludge thus dried is not liable to offensive decomposition. I have come to the conclusion that the precipitation process alone is not capable of producing a bright, clear effluent, nor complete deodorization. This is especially the case where the Sewage is strong or is undergoing incipient putrefraction. Hence filtration is necessary for obtaining a satisfactory effluent.

As the Sewage at Acton is received in the fresh state, the liquid has not yet lost its dissolved oxygen, nor has the greater

part of the organic matter been broken up into soluble, and therefore more hurtful products.

The larger portion of this organic matter is therefore removed partly by natural subsidence and partly by the precipitate formed by the Ferrous sulphate. The filtration removes all the suspended matter and a further purification is effected by the porous Magnetic Oxide which on absorption of organic matter in its pores ozidizes it by help of the dissolved oxygen existing in the liquid.

The filter beds at Acton have now been in use for fourteen months, the only cleansing having been the removal of the surface layer of sand.

I am, Gentlemen,
Yours truly,
(Signed) HENRY E. ROSCOE, F.R.S.

The eminent chemist, Dr. DUPRE, Chemical Referee to the Local Government Board, has also examined this material, and his report is most favourable upon it as an effective agent for the purification of water.

The Professors of the Army School of Military Hygiene at Netley have made very lengthy and exhaustive examinations, and have officially reported most favourable results to the War Department, and orders have since been received from Her Majesty's Government.

Polluted water taken from the River Thames *below London Bridge*, was passed through a filter composed of Polarite ; it was then analysed by R. H. HARLAND, ESQ., F.I.C. F.C.S., Analytical and Consulting Chemist, 37, Lombard Street, E.C., and *found to be purer than any of the drinking waters supplied by the London Water Companies.* This perfectly independent test was made at the expense of a user of "Polarite," who is in no way interested in the Company.

Copy Report of Professor Henry Robinson, M. Inst. C.E., Late President of the Society of Engineers, author of "Sewage Disposal," &c. :—

"7, Westminster Chambers,
"London, S.W.
"June, 1888.

"I have visited the Sewage Works at Acton on two occasions, the first shortly after their completion, and the second after they had been in operation for a year. My visits were for the purpose of observing the results of the International Company's system for purifying the sewage. In the first instance material called "Magnetic Ferrous Carbon" * is applied to the sewage as a precipitant, producing immediate deodorization and precipitation. The combined chemicals and sewage are allowed to remain quiescent in tanks for a period of two or three hours, after which the supernatant water is passed through a filter bed composed of "Magnetic Spongy Carbon" †, with a layer of sand upon the top to remove suspended matter. The action of this "Magnetic Spongy Carbon" * filter is remarkable, producing a permanently clear and inodorous effluent within so small an area as to lead me to form a very favourable opinion as to its being a valuable adjunct to sewage disposal works where a high degree of purity of the effluent is essential. No lime whatever is used in the process, which results in the bulk of the sludge being minimised and its manurial value increased.

"(Signed) HENRY ROBINSON,
"M. Inst. C.E."

It has been carefully examined by Dr. Angell, F.I.C., who reports the following experiments, demonstrating the potency of the material as an oxidizer.

* Ferozone. † Polarite.

"Experiment No. 1.—Ordinary domestic sewage was passed through 9 inches of "Polarite." By the permanganate test it was found that 94 PER CENT. of the oxidizable organic matter was destroyed or rendered innocuous.

"Experiment No. 2.—To demonstrate the destruction by oxidation of foul gases in solution. Taken a solution of sulphuretted hydrogen, equivalent to 4·2 grains of oxygen per gallon. After filtration by permanganate test, not a trace of sulphuretted hydrogen was left.

"Experiment No. 3.—I find that "Polarite," nothwithstanding that it permits the free transit of air and gases, is quite impermeable to atmospheric germs. An organic solution containing gelatine, cabbage water, turnip juice and urine, was found to keep unchanged for more than a year, the air being perfectly sterilized by its passage through the granules of "Polarite."

"These and other tests to which I have subjected the material, satisfy me that it is a very valuable substance for the filtration of water, sewage effluents, air and gases."

(Signed) A. ANGELL, Ph.D., F.I.C.
Public Analyst.

THE SANITARY INSTITUTE OF GREAT BRITAIN has, after long investigation, given The International Water and Sewage Purification Company its highest award, the Medal of the Institute.

HER MAJESTY'S GOVERNMENT FOR THE COLONIES, as well as the War Office, have also adopted the Company's process.

The potency of a substance as a purifying, deodorizing decolorizing and filtering medium is dependent upon and may be measured by its power of occluding and polarizing oxygen. The occlusion, or condensation of polarized oxygen takes place upon the surfaces both interstitial and superficial, consequently that material which presents the largest surface

in the smallest cubical space is the most powerful purifier and filterer. Spongy platinum fulfils best these conditions, and is consequently the most powerful purifier and filterer and the best insoluble oxidiser known. Its enormous price, however, shuts it out altogether from practical use. The use of Animal Charcoal has been suggested, but its high price and constant necessity of re-carbonizing prevent its adoption by Sanitary Engineers for the filtration of effluents, and Scientists now declare Animal Charcoal to be a dangerous material for filters, owing to the presence of Phosphates which are known to promote fungoid growth. It is thus evident that a good and cheap filtering medium *such as "Polarite,"* possessing great oxidizing powers and *quite insoluble,* is much needed.

SCIENTIFIC OPINIONS ON SEWAGE, SETTING FORTH THE DANGER ARISING FROM THE USE OF LIME IN CONNECTION WITH THE TREATMENT OF SEWAGE. Extracts from the *Builder*, April 16th, 1887 :—

"At Northampton, Iron Salts were used in the proportion of 4½ grains per gallon to 15 or 16 grains of Lime, with the result that the river was as foul after treatment as before. The Sewage at the outfall works was made to *appear clear* and the river seemed to be inoffensive, but after it had flowed a short distance it began to turn and was soon as black as ink—one putrifying mass. Nor is this experience confined to Northampton or to the action of either per-salt or sub-salt of Iron on Lime. At Bradford, at Clifton, and at Cheltenham the same thing has occurred."

"But that re-action of a most offensive nature may take place when small quantities of Lime are used with *apparently* good results at first, is indisputable. At Hertford the exact quantity per gallon now proposed by Mr. Dibdin was applied to a very weak Sewage. The result was that the effluent contained absolutely more foreign matter per gallon than the original Sewage, and that an abominable nuisance was created lower down the river at Ware."

Referring to the Metropolitan Sewage Works, it further states:—What public opinion will expect of the Metropolitan Board of Works before they make any further heavy demand on the ratepayers, we take to be this: first, to explain what effluent they propose to turn into the Thames; and secondly, to show what proof they adduce that the proposed treatment will not, by the secondary action of Lime and Iron, leave the river nearly as foul as it was before. If we take the figures cited by Mr. Dibdin, 13 per cent. of 20 grains, that is to say 2·6 grains of dissolved organic matter will be removed from the Sewage by the proposed process; add to this 90 per cent. of the total suspended matter, which comes to 24·3 grains, and we find that from a total of 87 grains of impurity 26·9 grains will be removed, leaving the effluent charged with 60·1 grains of foreign matter, plus of the 47 grains of precipitant as have not been thrown down."

At BURNLEY, where the Lime process of precipitation has been in operation, the Engineer reports:—"The effluent is of a very fair description as to colour, but, like all such effluents, must contain a large percentage of putrescible matter," and again he adds, "Precipitation, by the Lime process, as carried on here, produces, with care, what to the eye appears to be a very fair effluent, and, in my opinion, superior to the waters of the river into which it is discharged; but we are told that this effluent, however carefully manipulated by the Lime process, still contains a large quantity of putrescible matter in solution, which is totally unfit to be turned into a river or natural watercourse, and this process has been condemned by the Rivers Pollution Commission in their general report."

And again, the Rivers Pollution Commission, in reporting some years ago of the Lime process of precipitation, then in operation at Leicester, Tottenham, and Blackburn, say:—"In all these places the plan has been a conspicuous failure, whether as regards the manufacture of valuable manure or the purification of the offensive liquids."

In short, the concensus of opinion on the part both of scientists and practitioners, is conclusive that in no part of the process whatever must Lime be used.

THE COMPANY IS PREPARED TO GIVE ESTIMATES FOR THE SUPPLY OF THEIR MATERIALS FOR PURIFICATION OF SEWAGE, AND ALSO TO CONTRACT WITH PUBLIC BODIES FOR TAKING ENTIRE CHARGE OF SEWAGE WORKS.

ESTIMATES AND TENDERS GIVEN FOR LAYING DOWN FILTER BEDS FOR THE PURIFICATION OF WATER AND EFFLUENTS; ALSO FOR PURIFICATION BY THE "ASPHALEIAN" FILTER, A PATENT AIR STERILIZING AND WATER FILTERING APPARATUS, THE USE OF WHICH SAVES THE HEAVY EXPENSE AND SPACE REQUIRED FOR ORDINARY FILTER BEDS.

The "Asphaleian" apparatus (made in cast or wrought-iron, as also for lightness in steel) is charged with "Polarite," and the sterilized air, freed from all germs, is admitted *automatically.* This sterilized air is then absorbed by the purified water, causing it to become fresh and sparkling like spring water.

"Asphaleian" filters, suitable for public institutions or private establishments, can be had at prices ranging from £2 upwards, according to quantity of water to be purified.

Sanitary Authorities, Municipal Bodies, Corporations, Water Companies, Filter Manufacturers, and others supplied. Special quotations given to Public Bodies and Engineers.

Further particulars, with prices, may be had on application to the International Water and Sewage Purification Co., Ld. 11, Queen Victoria Street, London, E.C.

FRANK CANDY
Managing Director.

October, 1888.

OPINIONS OF THE PRESS
ON THE
"INTERNATIONAL"
SYSTEM OF PURIFICATION OF SEWAGE.

From "The Times," April 8th, 1887 :—

"The ceremony of laying the memorial stone at the Acton Main Drainage Works was recently performed by Mr. William Roebuck, C.E., Chairman of the Acton Local Board. The works, which are of an extensive character, were designed by Mr. C. N. Lailey, the engineer to the Board, and will give to Acton a perfect drainage system. The ceremony was attended by the members of the Board and a number of the leading inhabitants. The scientific interest, however, centred in the treatment of the sewage, for the drainage system includes the latest improvements and appliances for the purification, by a new chemical treatment, of the sewage of this large and rapidly-growing western suburb of London. This process is carried out without the use of lime, which is an objectionable system sometimes resorted to. The precipitant consists of a new and cheap material—namely, Magnetic Ferrous Carbon (Ferozone), which not only causes rapid precipitation, but fixes the ammonia and phosphoric acid, thereby adding to the manurial value of the residue. Upon the occasion in question the contents of one of the large sewage tanks were successfully treated, the solids precipitated and the effluent deodorized and rendered clear and bright to a remarkable degree. The resultant sewage sludge was also pressed without the use of lime, with the consequent enhancement of the manurial quality of the precipitate. A cake of the compressed sludge was examined and found to be exceedingly dry and solid, yet of a powdery character and with-

out any of the offensive odour of pressed lime sludge. The purification of the sewage was successfully carried through to the satisfaction of the Board and their engineer, and it would appear that the long sought for materials which will re-act upon sewage without the use of lime are here to hand. This forms a highly important feature in the science of sewage disposal, more especially as the materials are obtained by an inexpensive treatment of waste products. The new precipitant (Ferozone) is supplied to the Local Board by the Water and Sewage Purification Company, of 18, Mansion House Chambers, London."

"Iron," April 13th, says:—

"Its success and its economy combine to mark it as a practical departure in the science of sewage disposal, in the history of which it constitutes a new chapter."

"Engineering" says, referring to Acton:—

"The drainage system includes the latest improvements and appliances for the purification, by a new chemical treatment, of the sewage *without the use of Lime.* The sewage sludge is pressed *without the use of Lime*, with a consequent saving of the manurial quality of the precipitate."

From "The Builder," September 3rd, 1887:—

"Several months ago a detailed account was given in "The Builder" of some experiments in the treatment of sewage under the International system, which is promoted by the International Water and Sewage Purification Company:—

The company contend that by their chemicals they retain all the original manurial properties of the sludge which are driven off by the lime, which liberates the ammonia and renders the phosphoric acid insoluble, and therefore of no use to plant life."

"The Standard," August 6th, 1887, says:—

"The new main drainage works of Acton, designed by Mr. C. N. Lailey, Engineer to the Acton Local Board, were

formally opened yesterday by the Chairman, Mr. W. Roebuck, C.E., in the presence of a large company of gentlemen interested in the question of sewage treatment. The system adopted is that known as the International system. The process removes upwards of 90 per cent. of the oxidizable matter, which would putrefy if allowed to pass into the river untreated. The purified effluent appeared to be as clear as that from the Water Company's main. The refuse is formed into cakes and ground into powder, being afterwards put into sacks for the purpose of being sold as manure. The Company claim that their process retains all the original manurial qualities in the sludge. The Chairman (Mr. Roebuck) presided at the luncheon which took place in the grounds of the works, which were beautifully laid out with flower beds."

"The Sanitary Record," September 15th, 1887, says :—

"An improved process for the purification of sewage, whereby it is claimed that our rivers may be brought to their original state of purity, has at length been put into practice at the new and complete Sewage Works at Acton, publicly opened on Thursday last by the Chairman of the Local Board, W. Roebuck, Esq., C.E., in the presence of about 250 gentlemen interested in the science of sewage treatment.

The system adopted by the Local Board of Acton, and ably carried out by the engineer to the Board, C. N. Lailey, Esq., is that known as the International process, which had previously been subjected to the most severe tests. It consists, firstly in effecting precipitation and destroying disease germs in the effluent. Secondly, in destroying the putrescible organic matter in solution. This is effected by passing the effluent through Magnetic Spongy Carbon (Polarite), which has the extraordinary power of rapidly creating ozone or magnetised oxygen, whereby as much as 96 per cent. of the oxidisable matter in solution can be removed. These results are obtained by abandoning altogether the objectionable use of lime now pretty generally understood to be the great cause of

highly offensive putrefactive changes, which invariably arise whenever lime is used. In fact, the leading chemists and scientists declare that lime creates an intolerable nuisance, and accordingly welcome any cheap precipitant having deodorising properties. Such a precipitant the International Water and Sewage Purification Company, of 11, Queen Victoria Street, City, claim to have succeeded in producing. The soluble salts in this precipitant can be had either as chlorides or sulphates, or both. The chemical action of these salts is most potent when in combination with "Polarite" in a finely divided state, and it is this special production (the patent rights of which belong to the International Purification Company) which is said to make the International system of sewage purification quite unique. The managing director, Mr. Candy, in responding to the toast, "Success to the International Purification Company," proposed by the Local Board, stated that by the International system the whole of the sewage of the Metropolis could be effectually purified, and the effluent disinfected and deodorised at a small cost in comparison to the yearly outlay now incurred by the Metropolitan Board for chemicals to disinfect the effluent after partial precipitation; in fact, Mr. Candy demonstrated that fish would live and thrive in a sewage effluent such as produced by the International system, and undertook with a filtering area of one acre to purify five millions of gallons of sewage effluent daily.

An interesting feature of this new and combined process is that the manurial value of the sludge is stated to be increased by reason of the ammonia and phosphoric acid being fixed and retained for use on the land, whereas when lime is used both the phosphoric acid and ammonia are lost; and the sludge being moreover, pressed with the lime in, hardens into a kind of cement, which lies in large lumps on the land for an entire season. By the International system the sludge cake is made friable, consequently forms a valuable top-dressing for grass, as well as corn and roots. A recent analysis shows that all the

suspended matter in the sewage at Acton was removed, as also as much as 96 per cent. of the organic matter in solution. Such a result has hitherto been thought impossible. The Acton Local Board would thus appear to be justified in asserting that they have adopted a good and economical process.

The works as now constructed are capable of treating the sewage of a population of 20,000, but the permanent machinery is of sufficient power to deal with a much larger population."

"The Lancet," 10th September, 1887, says, in referring to the

DRAINAGE SCHEME IN THE LOWER THAMES VALLEY.

"The Acton parish has soon followed the suit of some of the other local authorities along the Thames valley in providing for its district a system of sewage disposal, which enables it to pass into the river Thames a clarified effluent water, instead of polluting crude sewage. Acton would seem to have taken rather an enterprising step in this matter, by adopting a system of sewage purification which has not hitherto been in operation at any public sewage works. The system is that of the International Water and Sewage Purification Company, which differs in many salient points from the generally prevailing 'lime process' of sewage clarification. In this case no lime, indeed, is used. The principal substance in this new system is magnetic ferrous carbon or Ferozone—prepared from a rocky material hitherto considered useless—rich in ferrous alum and carbonised iron. In the process of precipitation this "Ferozone" is used in combination with what are termed 'compound sewage salts,' consisting of proportions of sulphate of alumina, sulphate of magnesia, and sulphate of calcium. The company, it seems, do not claim to have made a discovery of any new substance with startling properties. The operation and effects of the process are based upon well-known chemical principles, and it is in the mode of

preparing and applying this substance to the purposes of water and sewage purification that the company think they have found something which goes a long way to solve the problem of treating sewage effectively and economically. It is found that by virtue of the soluble iron and alumina salts in this Ferozone, it acts as a rapid precipitant, and, being carbonaceous and porous, that it also acts as a disinfectant and deodorizer. The complete process of clarification does not end in precipitation. In order to render the effluent water faultlessly pure, it is passed through a bed of "Polarite" (magnetic spongy carbon) and sand. At Acton it was noticed that the effluent water as it came direct from the precipitation tanks bore a reddish tinge, but chemical testing proved that this discolouration was due to the presence of iron, which would have a purifying effect than otherwise upon the river water. But the effluent water, after being passed through the bed of "Polarite" appeared quite bright and clear. A telling demonstration of the purity of the filtered effluent was the fact that a number of gold-fish were swimming about gaily in a large globe filled with the filtered effluent. The sight proved a most interesting one to the many sanitary engineers present at the opening of the works on Thursday week last. A recent analysis showed that as much as 96 per cent. of putrescible organic matter in solution was removed, as also all suspended matter. It would seem that here is solved the question how to secure a pure effluent without the necessity of acquiring large areas of land for irrigation, also without the pecuniary and sanitary risks attending a sewage farm. The filter-bed at Acton, where the scheme is to provide for the requirements of a population of 20,000, occupies an area of less than seventy feet square, "Polarite" being so efficacious that it can operate in a considerably less space than most of the filtering materials made from clay deposits or earthy substances carbonised. It it well known that the stratified structure of these latter substances interferes with their filtering powers, except in the direction of the laminæ, and are therefore liable to silt up and become impervious to moisture. Another

feature of the new process is the character of the resultant sludge. The liquid sludge passes from the precipitation tanks into a rotatory agitator, where more of the company's chemicals are added, for the purpose of producing practically a second precipitation, and to further ensure the impossibility of putrefactive changes taking place in the solid sludge after being pressed. The company contend that by their treatment of the sludge the manurial qualities in it are fixed by the further addition of the Ferozone, and that if the same quantity of lime had been added, as is the case in the lime process, the manurial properties in the shape of ammonia would be driven off, and the phosphoric acid rendered insoluble and of no use to plant life. A ready demand is therefore expected for the sludge, which *is* to be sold as manure in powder."

We extract the following from "Sanitary Engineering," of September 2nd, 1887.

"The system adopted by the Local Board of Acton, and carried out by the Board's Engineer, Mr. C. Nicholson Lailey, is that known as the International process, which had previously been subject to the most severe test, and consists firstly in effecting precipitation and destroying disease germs in the effluent; and also in destroying the putrescible organic matter in solution. This is effected by passing the effluent through magnetic spongy carbon (Polarite) which has the extraordinary power of rapidly creating ozone, or polorized oxygen, whereby as much as 96 per cent. of the oxydisable matter in solution can be removed. These marvellous results are obtained by abandoning altogether the use of lime, now by some thought to be the great cause of the highly offensive putrefactive changes which frequently arise whenever lime is used. Any cheap and effectual precipitant having deodorising properties would therefore be welcomed. The soluble salts in this International precipitant can be had either as chlorides or sulphates, or both; the chemical action of these salts are most potent when

in combination with Polarite in a finely divided state, and it is this special production (the patent rights of which belong to the International Purification Company) that makes the "International" system of purification quite unique.

An interesting feature of the new and combined process is that the manurial value of the sludge is increased by reason of the ammonia and phosphoric acid which are driven off in the lime process being fixed and retained for use on the land; sludge moreover, pressed with lime, hardens into a kind of cement, and lays in large lumps on the land for an entire season, whereas the International sludge is friable, and the soluble constituents are readily assimilated by plants.

Acton is to be congratulated on having a perfect system of sewage purification without a nuisance; and we trust that the sanitary and other advantages of this rising western suburb of London will be fully appreciated by the rapidly-growing population.

Much credit is due to the Board's Engineer and his Clerk of the Works, Mr. William Swaker, for the able way in which this important sewerage system has been carried through."

The "West London Observer," of Saturday, 27th August, 1887, writes as follows:—

"The system adopted at Acton is known as the International system, promoted by the International Water and Sewage Purifying Company, in which the usual lime precipitant is discarded. It is claimed for it that while it produces an effluent water, which rather purifies than otherwise the river water into which it may flow, it retains in the sludge a larger portion of the manurial qualities than is possible with the lime process. The Acton Board, having become satisfied with the thorough efficiency and economy of the scheme, have entered into a provisional agreement for seven years for the treatment of the

sewage by the Company's system, at the new sewage works. The filtered effluent, clear and bright, was tested chemically on the spot by Dr. Angell, for organic matter, and notwithstanding statements made as to the impossibility of removing organic matter in solution, this process, it is asserted, removes no less than 90 per cent. of the oxydisable matter. The liquid sludge passes from the tank into a sump, from which it is pumped into a rotatory agitator, where more of the Company's chemicals are added, for the purpose of producing practically a second precipitation, to further insure the impossibility of putrefactive changes taking place in the solid sludge after being pressed. Sludge has hitherto been made by the addition of lime, without which the sludge would not press in the ordinary press. The Company contend that by their treatment of the sludge the manurial qualities originally in it are fixed by the further addition of Ferozone, and that if the same quantity of lime had been added the manurial property, in the form of ammonia, would be driven off and the phosphoric acid rendered insoluble and of no use to plant life.

The "Richmond and Twickenham Times" states that—

The purification is effected by a combined process of precipitation and filtration, a special feature being the absence of lime in the ingredients used for this purpose. The material used for precipitation is Ferozone, supplied by the International Purification Company. After precipitation in tanks the surface liquid is passed through a filter-bed composed of granulated Polarite, and the purified effluent from this discharged by an outfall sewer running through the parish of Chiswick into the river Thames near Chiswick Eyot.

The following account of what took place on the occasion of the public opening of the New Sewage Works, Acton, is condensed from the columns of "The County of Middlesex Independent" :—

At 2.30, accompanied by a numerous throng, Mr. Roebuck proceeded to open the works. The first step was made in the direction of the engine house, where Mr. Roebuck first turned on steam to the pumping engine and then to the engine for mixing the chemicals necessary for precipitation and for driving the sludge into the presses. Mr. Roebuck then shortly explained the nature of the process to which the sewage was subjected on passing to the tanks. These latter he observed were three in number, and each would hold nearly 140,000 gallons of sewage and could be filled very rapidly. They could begin to fill a tank with sewage, and within three hours from the time of commencement, the effluent could be run off from the sludge. He drew attention to the fact also, that no lime was used in the process of precipitation. He then asked them to accompany him to the filter beds, on to which would be run some effluent which had been lying overnight in one of the tanks. The outfall sluice was opened by the Chairman, and the water flowed on to the filter bed, made of a new composition peculiar to the scheme adopted by Acton. Samples of the new effluent were handed round and some more venturesome persons even went the length of tasting. After the works had been duly inspected by the guests, a large party assembled in the laboratory, where Dr. Angell was ready to explain the new system. He (Dr. Angell) said that Mr. Roebuck in taking them round at the opening of the works had shewn what could be seen as a practical test. As the chemical representative of the Purification Company it was his duty to lay before them the scheme in a somewhat more detailed manner. They did not claim to have brought a new invention before the world. As they were aware the intelligence of the chemical world in this country and that of the civilised world had for years past been brought to bear upon the question of sewage treatment. The International Sewage Purification Company had been gleaning facts from all places and selecting the strongest as strands with which to form as it were a rope which would bear the strain now put upon it for sewage purification The object which they had kept in view was to obtain a good effluent with-

out the use of lime. They, in common with many others, had come to the conclusion that lime was no longer necessary, although they knew that a fairly good looking effluent could be obtained by its use. But he maintained that from a chemical point of view it was a species of vandalism to use lime. Those who trusted to lime were living in a kind of fool's paradise. They breathed an atmosphere which would only bring them to a collapse; he meant by that that although the effluent might appear clear enough, it still would contain a quantity of organic matter in consequence of the lime used, which would in a short time create a nuisance. The company had succeeded in producing a substance which would purify sewage without lime. The material they used was Ferozone, which depended chiefly upon the ferrous salts contained in it for its efficiency. It was very well recognised that ferrous salts were among the best antiseptic materials known. After giving an analysis of the Ferozone, he observed that the magnetic portion of the carbon was peculiar to the material used in the process of purification. The company did not depend entirely on the precipitation, although it was possible for them to obtain by precipitation a perfectly pure effluent. But it was found better to purify completely by filtration after precipitation as they had seen that day. Notwithstanding that it had been said that there were no means practicable of entirely destroying organic matter, the process which they had seen at work could destroy 90 per cent. of that matter, the solid matter being removed by precipitation, and the soluble by filtration, and they could see the results when they looked at the effluent. Dr. Angell then shewed a sectional drawing of the filter bed. The claim for that filter bed was not its novelty, because filtration had been tried over and over again, and others would have succeeded had they composed their filter of a substance which would retain its chemical and physical properties. The filtering material of the Company was free from stratification and that differentiated it from those substances which had been tried before, all materials previously used being more or less stratified. He then minutely described the constitution of Polarite. It was a true filtering material, which

exposed in the smallest superficial area the largest possible surface to the oxydisable liquid as it passed through. That was the secret of a good filter. He then, for the purpose of demonstrating the lasting nature of the Company's filters, shewed a sample of effluent which had been turned out of a small filter of 1ft. cubic contents, the filter having been in use for 18 months; it was absolutely clear, and on inviting those present to smell it, he observed that the nose was one of the best tests to apply to effluent. If there was no smell arising from it after standing for several hours in a hot sun, it might be assumed to be good. Alluding then to the length of time which the effluent would keep, he produced a sample which had been taken on the 25th March, in which an interesting effect had taken place. That was the development of a form of organic life which was a highly organized one when compared with the morbid condition of life which generally took place in foul effluents; had the effluent been foul the ordinary sewage fungus would have been observed instead of, as now present, a green growth. After exhibiting a few more samples of well kept effluent, Dr. Angell remarked that the system had been tested in the strongest possible manner before a number of highly qualified gentlemen. He then passed round for observation microscopical sections of the Polarite, observing that the minuteness of the pores prevented the passage through of the slightest particle of matter. The interesting observations of Dr. Angell were brought to a close by the inspection of several gold and other fish alive and flourishing in a tank containing the filtered effluent, on which he remarked, that the fact proved to them that there was nothing injurious in their effluent to fish life, a question which was very generally asked in regard to effluents.—The company then adjourned to a large marquee where a luncheon was provided.

Mr. Candy, the Managing Director of the International Purification Company, in responding to the toast of success to the Company, stated that it was not established for the purpose of rigging the market for shares, but was composed of a few hard

workers who were determined to make a success. (Hear, hear.) They had been working silently for years with a view of discovering a material to solve the sewage difficulty, and he thought they had seen that day the success that had been achieved. (Cheers.) They had now a material by which they could purify sewage without the aid of lime. Many would tell them that it was impossible, but all those who had heard Dr. Angell would not only be convinced that it was possible, but that with the absence of lime they could get a better effluent. He might state that although they could purify sewage by simple precipitation, they regarded the process of filtration as a most important one. By it the Thames might be brought to its former degree of purity. (Hear, hear.) They had seen fish alive in the effluent produced by their process, and it was only a question for the Metropolitan Board to consider whether they would spend about £120,000 in laying down a series of filter beds, to purify their effluent. The Grand Junction Water Company had, for instance, eight acres of filter beds. If the Metropolitan Board would lay about five times that area they would be able to filter the whole of the sewage of London after precipitation, and give sufficient area for the revivification of the beds to ensure their permanent use; by that he meant that the Polarite would last practically for ever. The surface must be scraped occasionally as was done in the case of other filter beds, and this presented no difficulty. It was done by the water companies once a month, or every three months as the case might be. The sand was washed and replaced; but sand filtration was simply a system of straining, but there was one of aëration and oxidisation; the oxidisation took place in the pores of the Polarite, into which no solid organic matter could enter. The result was the impossibility of fouling the filters, so that they might rest assured that in the new beds laid down for Acton, they would be safe in getting such an effluent, as had never flowed into the Thames before. He only wished to add that the Company had been purifying water on the Continent, and if the system was good for water, it was also good for sewage.

THE SOCIETY OF ENGINEERS' VISIT TO THE ACTON SEWAGE WORKS, WEDNESDAY, OCTOBER 19th, 1887, to inspect the "International" process of Purification, as carried out by the INTERNATIONAL WATER AND SEWAGE PURIFICATION COMPANY, of 11, QUEEN VICTORIA STREET, LONDON.

After the works had been carefully inspected, and when the visitors were leaving, THE PRESIDENT (Professor Robinson, M. Inst., C.E.), addressing Mr. W. Roebuck, C.E., the Chairman of the Acton Local Board, said:—I wish, sir, on behalf of the Society of Engineers, to thank you for the opportunity you have afforded us of visiting these interesting works, and I wish also to express my congratulations to you and to the ratepayers of the district upon the successful result of what I know has been a very long and uphill fight in this place. I think I may say that, from an engineering point of view, the works themselves and their design commend themselves to every one of us, for they have been constructed on economical principles, though with an amount of taste in the buildings which I think all the younger members of the profession can take an example by. The working of this particular system of sewage treatment is in its infancy, and as we are promised a paper for one of our meetings by Mr. Lailey, the engineer, we shall have a future opportunity of considering all the details of cost, method of treatment, degree of efficiency, and matters of that kind. On those grounds, therefore, I am sure you will not wish me to express my opinions to-day upon matters of fact not already before us. Considered in their sanitary aspect, however, I am of opinion that, as far as can be judged at present, these works are a complete success. We have, of course, as practical engineers, to consider not only efficiency, but the cost of treatment with reference to population and the quality of the sewage. The sewage which is being shown under treatment to-day is borrowed from the sewers of the

Metropolitan Board of Works (and a pretty foul specimen it is), because as yet comparatively few of the houses in the district are connected with the new Acton Sewerage System. But the test put before us to-day seems to be a conclusive one from a sanitary point of view. The works are conducted without the slightest smell, without a trace of the odour, which we have hitherto been in the habit of regarding as an almost absolute essential (and which has certainly been an invariable concomitant) of sewage works. The reasons which Dr. Angell has assigned for the efficacy of the process of treatment here adopted are obviously the right reasons; and I think I am fully justified in saying that the process which we have seen here at work to-day is one which has before it a very great future. If the system of which we have seen to-day the beginning is carried out in its entirety, I *shall no* doubt have a future opportunity of expressing a very confident opinion of its success as compared with that of other systems which we have seen in operation at other works, that is to say, from a sanitary point of view. I say this (if I may be permitted to say so) as an old sewage "expert." The engineering works themselves, as I have already said, also commend themselves to us, and in conclusion, I would say that the Society of Engineers desires me to express to you, sir, their very high appreciation of what has been achieved by you at the Acton Local Board, aided by your able engineer, Mr. Lailey. (Applause.)

Mr. W. Roebuck, C.E., Chairman of the Local Board, in reply, said:—Professor Robinson and Gentlemen, as an old member of the Society of Engineers, I had great pleasure in welcoming you here to-day, and as Chairman of the Acton Local Board, it has given me additional pleasure and gratification to hear what has been said by you to-day with reference to these works, by the completion of which we hope, and believe, that we have effectually solved the sewage difficulty in this district. The International process which we had adopted was not only the best, but the cheapest we could find for the purification of the sewage without any nuisance. It will afford the Members of the

Board and myself great pleasure to see you and conduct you over the works at any future time. (Applause.)

The following is the result of the analysis of Dr. Angell, F.I.C., of average samples of the Crude Sewage, and of the effluent from such sewage taken by himself in the presence of the President and Members of the Society of Engineers:—

The Crude Sewage, after removal of the solids in suspension, contained **7·2** grains of organic nitrogenous matter in solution per gallon of sewage, whereas the effluents, after treatment of the sewage with Ferozone and Polarite, was bright, free from odour, and colourless, and contained only **0·47** grains of the nitrogenous matter, being less than half a grain per gallon. The analysis further showed that all the solids had been deposited, and 93·5 of the nitrogenous organic matter in solution destroyed by the International process, a most remarkable and highly satisfactory result of sewage purification when contrasted with the lime and iron or lime and alumina processes, which, although removing most of the suspended matter, *actually increases* the dangerous organic nitrogenous matter in solution, causing pollution, putrefactive changes, and growth of sewage fungus on the banks or streams into which the sewage effluent from these processes flow.

The following is taken from the "West Surrey Times" of January 21st, 1888, and reported in consequence of the visit to Acton of the Drainage Committee, of Guildford, who are seeking a process of Sewage disposal.

"Acton, not unjustifiably, is extremely proud of its sewage-works. As has already been mentioned, the special feature of the system is the exceptional degree of purity to which the effluent is

brought—an essential result in view of the fact that the effluent has to be conveyed for several miles before discharge into the river. When, in addition, it is understood that this result is attained without irrigation, it will be obvious to all who know anything of sewage matters that the chemical process must be one of more than ordinary efficiency. Such, in brief, is the Acton system, which is deservedly attracting a good deal of attention amongst sanitarians."

The following is from "The Metropolitan" of 18th February, 1888 :—

"THAT the best method of disposing of and purifying sewage has always been an open question is evidenced by the fact that during the past forty years several hundred patents have been taken out for the purpose. Many of them were palpably absurd and chimerical, while the majority consisted in the addition of chemical solutions and solids, which not only added to the bulk of the sewage, but set up mischiefs that were worse than the effects of simple sewage. Still we have been getting nearer and nearer to the desired object, and it is possible we are much closer than most people suspect; indeed, we are almost prepared to believe that a perfect system of sewage treatment has now been discovered. The system to which we refer is not confined to the laboratory, but is daily working with most satisfactory results at the sewage works of the Acton Local Board. Here the sewage of a large and growing district is received, treated without the addition of lime or other bulky substance, and an effluent is provided which is almost the *ne plus ultra* of chemists. We give herewith a sketch plan of the works in question. The mechanical operation is exceedingly simple, and so is the chemical action, but its importance in dealing with the difficult question of sewage treatment is very great.

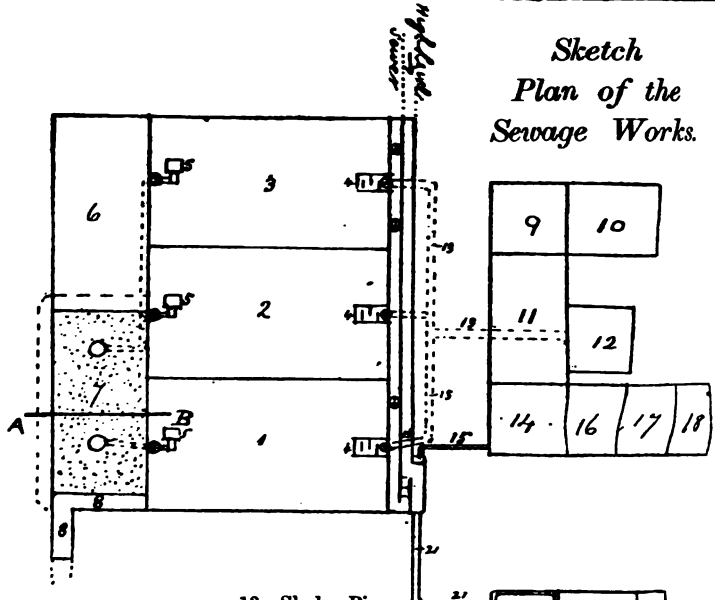
Although we make it a rule to confine ourselves almost exclusively to the practical aspect of a process, we must, in this case, trouble our readers with some scientific particulars, without

which the system that has been introduced by the International Water and Sewage Purification Company, of 16 and 18, Mansion House-chambers, E.C., cannot be properly understood or appreciated. In the first place an important result is achieved by not using lime. Lime, it is true, will produce a comparatively clear effluent, but it dissolves a quantity of organic matter into solution which soon develops into a serious nuisance, as is witnessed near the outfalls of all lime-treated works. It is evident that what is required is a material which, while giving a clear effluent, will reduce the organic matter in solution instead of adding to it. Such a material the Company have found, and it is entirely free from all the objections raised against the ordinary precipitation processes. An iron-stone rock has been discovered in Wales which, if not yielding fabulous ounces of gold to the ton, is likely to prove an El Dorado to the Company, inasmuch as it can be converted into a filtering and purifying material of exceptional value. The stone, after having been subjected to a special treatment, is found to have become not only porous but magnetic, and possessed of certain chemical and physical attributes. The material, after treatment by heat, is termed Polarite, and when engaged in the purification of water, occludes oxygen upon the surface of its infinitesimal pores, and, becoming polarised, produces ozone which renders microbic life insupportable. The material, when broken small, forms one of the best filtering substances imaginable, for not only are all mechanical impurities removed, but the water is highly aerated with its most important constituent, oxygen. An example of the potency of Polarite may be found in relation to the artesian-well water supplying the large block of buildings, No. 11, Queen Victoria-street. Here a well was sunk by the owners of the building, in order to escape the enormous charge for water its high assessment would enable the New River Company to demand. The water, though not absolutely injurious, is of a faint amber colour, and deposits a sediment in the water-bottle. As about 500 suites of offices are supplied from the well, it was necessary the water should be purified. This is done by a

filter charged with Polarite, and we can testify to its success. We had an opportunity of taking samples of the water before and after filtering, and can state that while the former was, when seen through the usual 2ft. stratum, of a decided yellow, the latter was white and sparkling. We believe the Company have also a process of "sterilising" the air in the filter, so that no impurities can enter the filtered water. This process is one that will no doubt have to be carried out by the Commissioners of Sewers when their artesian well is completed, as probably the water therefrom will be equally coloured.

For the treatment of sewage the process is as follows:- In a building adjacent to the inflow of the sewage, the Ferozone, which contains salts of iron, alumina, calcium, and magnesia, is ground up and mixed with water, and the mixture runs into the delivery channel of the sewage and mixes thoroughly with it. The combination then passes into the precipitating tanks, but a chemical change in the character of the sewage has already taken place. In the tank a coagulation of the organic matter with the salts takes place; then the ferrous salts defecate the organic matter that is in solution, and, lastly, the insoluble particles of Polarite, by their exudation of oxygen and ozone, prevent decomposition. After remaining for about three hours, the precipitation is complete, and the effluent is harmless and capable of being sent into any river; the process, however, does not end here. The tank effluent, which is almost clear and free from smell, is filtered through a bed the foundation of which is shingle, upon which is a layer o pea gravel, above that six inches of sand, and upon this mixture of Polarite and sand and gravel. Above this is a laye of sand nine inches in thickness, and on the top of all or inch of coarse Polarite. The effluent after passing throug these strata is clear, bright, and much more potable than ma waters that are drunk. So pure is the liquid that it is found t extraordinary proportion of 94 per cent. of the oxydisable matt has been removed.

Sketch Plan of the Sewage Works.



1, 2, 3 Precipitating Tanks

4 Floating Entrances

5 Floating Delivery

6 Reserved for alternate Polarite Filter Bed

7 Polarite Filter Bed

8 Culvert for Purified Effluent

9 Sludge Cake Grinding and Drying House

10 International Manure Stores

11 Sludge Pressing House

12 Sludge Well

13 Sludge Pipes

14 Magnetic Ferrous Carbon or Ferozone Mixing House

15 Ferozone Delivery Conduit

16 Sludge Mixing House

17 Ferozone Stores

18 Office and Laboratory

19 Pump House

20 Pump Well

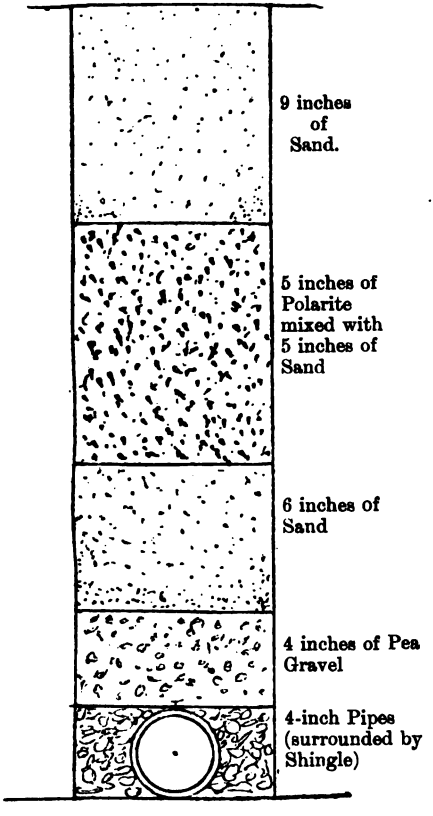
21 Pipe for Sewage

22 Boiler House

23 Coal Stores

24 Water Tank

Section on line AB.


9 inches of Sand.
5 inches of Polarite mixed with 5 inches of Sand
6 inches of Sand
4 inches of Pea Gravel
4-inch Pipes (surrounded by Shingle)

VERTICAL SECTION
OF
"POLARITE,"
FILTER BED.

Scale—$\frac{1}{8}$ of an Inch to 1 Foot.

The engraving shows, Fig. 1, ground plan of the sewage works at Acton, which were designed by Mr. Lailey, engineer to the Acton Local Board, and superintended by Mr. Swaker, clerk of the works, who takes great interest in the process. The arrangement of the works is a high testimony to the skill of Mr. Lailey, and is alone worth making a journey to see. In the plan, No. 20 is the pump well, 36 feet deep, from which the low-level sewage is raised, which passes *via* the pipe 21 into the open culvert. The high-level sewage arrives at the opposite end of the works. No. 14 is the house in which the Ferozone is mixed. Nos. 1, 2, and 3 are the precipitating tanks, and 6 and 7 are the filtering beds, No. 6 being held in reserve. Fig. 2 shows a section of the filter. The sludge is drawn off in liquid form to a "sump," and is pumped thence into a rotatory agitator, where means are taken to prevent the possibility of putrefactive changes taking place, and it is then pressed into cakes, dried and ground up. For manurial purposes the powder is of great value, for the ammonia and phosphoric acid are fixed and rendered valuable for plant life. There can be no doubt that the International Water and Sewage Purification Company—of which Mr. F. Candy is the energetic Managing Director—have solved three important problems—viz., how to treat sewage without lime; how to produce a practically pure effluent; and how to obtain a sludge which is comparatively small in quantity, that can be easily manipulated, and is of undoubted manurial value.

AT THE INAUGURAL ADDRESS OF THE SOCIETY OF ENGINEERS, the PRESIDENT, A. T. Walmisley, Esq., member of the Institute of Civil Engineers; Fellow of King's College, London, after alluding in complimentary terms to the International Company's process, added "Where no lime is used in precipitation of the sludge, as at Acton, the manurial value of the precipitate is increased."

THE INTERNATIONAL

& SEWAGE PURIFICATION CO.,

LIMITED.

rams and Telegrams :—"CIMOLITE," LONDON.

ıeen Victoria Street, London, E.C.

MINES—

Abercrave, South Wales.

Sole Manufacturers of—

IC SPONGY CARBON (POLARITE), for large lter Beds and Domestic Filters.

TIC PRECIPITANT (FEROZONE), for Sewage Purification and Deodorization.

ATIC DISINFECTANTS, "ASPHALEIA," for General Sanitary Purposes.

ATIC DAMP-PROOF PAINTS.

ATIC FIRE-PROOF PAINTS.

PROOFING SOLUTIONS, for Fabrics and Timber.

LESS MAGNETIC PAINTS, for Metals.

LESS MAGNETIC ANTI FOULING COMPOSITION, for Ships' Bottoms and ot.. Submerged Surfaces.

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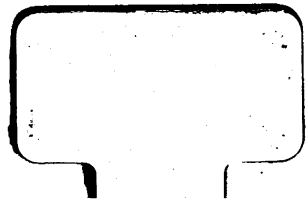
ERILIZED AIR & WATER FILTER, "THE ASPHALEIAN."

OUL WASTE WATER PURIFIER, for Factory Effluents.